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“Creating Values through Optimal Decision Making in Experience Economy”

Edited by

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Welcome Message from Conference Chair

Welcome to the 11th International Conference Decision Sciences Institute (IDSI) and 16th Annual Conference of the Asia Pacific Decision Sciences Institute (APDSI) in Taipei. The theme of this year’s Conference is “Creating Values through Optimal Decision Making in Experience Economy.” We have received 212 submissions and 108 papers are accepted into the final program that consists of twenty-four sessions. Among them, 82 full papers are included in the Proceedings. The topic areas of these papers include Accounting, Case Studies, Consumer Behavior, Decision Making, Decision Systems, Finance and Financial Management, Green Management and CSR, Healthcare Management, Information Systems, Information Technology and Services, Innovative Education, International Collaborative Work, International Business Management, Internet and E-Business, Operations Management, Organizational Behavior, Quality and Productivity, Service Operations, Service Systems, Social Networks, Statistics and Decision Analysis, Supply Chain Management, Technology and Management, and Web Services.

It is our great honor to present Prof. Samuel K.C. Chang, Professor and former President of Chung Yuan Christian University to give us an opening address on leadership and decision making. In addition, we have scheduled three keynote speakers including Prof. Stephen C. Hora from University of Southern California in the U.S., Prof. Asoo J. Vakharia from University of Florida in the U.S., and Prof. Kee Young Kim, my long-time friend and APDSI founder, from Kwangwoon University in Korea. They are presenting their recent research in decision making in anti-terrorism, green supply chain management, and technology innovation strategy. Following these speeches, we have produced two Industry Panel sessions to discuss the issues of cloud services and logistic development in Asia Pacific. The panel will be held in the afternoon of July 13 from 3:50pm to 6:00pm. The panelists include industry experts from Chunghwa Telecom, DHL, FedEx, HCT Transportation, IBM, Mindext, Microsoft, etc. We thank very much the panelists and the diligent moderators: Prof. Helio Y.L. Yang from San Diego State University in the U.S. and Prof. Johannes K.H. Chiang from National Chengchi University in Taiwan.
This joint conference of IDSI and APDSI is a golden opportunity for the scholars like you and me to share research ideas and get informed about the latest development in the fields. We could meet other leading professionals from around the world so as to establish a research network and engage in future collaborations. In this conference, we warmly welcome two hundred twenty-one scholars from fifteen countries, such as Australia, Canada, China, Cyprus, Finland, Hong Kong, Italy, Japan, Korea, Singapore, Taiwan, Thailand, England, U.S.A., and Vietnam.

In closing, we would like to thank you for your participation in this conference, without which it is impossible to be successful. We would also like to thank all the reviewers, the program committee members, the funding sponsors, track chairs, and session chairs, who all have contributed their effort and financial support to this conference. Special thanks go to our conference staffs, especially Laurence Chang, Thomas Chang, Patricia Chang, Dr. Limin Tsai, Jason Liu, and James Kao, who have planned and executed this conference event tirelessly for over a year.

The conference is sponsored by National Chengchi University, National Science Council, Bureau of Foreign Trade of Taiwan, Department of Information and Tourism of Taipei City, and Hill Ever Technology Corp. There are several co-organizers including Chinese Institute of Decision Sciences, National Taiwan University, National Sun Yat-sen University, National Central University, Feng Chia University, and Yuan Ze University. We would like to thank all the sponsors and co-organizers for their generous support. Finally, on behalf of the entire Program Committee and the Grand Hotel, we sincerely wish you have a very productive and memorable experience in Taipei during the Conference period.

Cordially yours,

Eldon Y. Li
Conference Chair of IDSI-APDSI 2011 and
University Chair Professor of
National Chengchi University, Taiwan

July 2011 in Taipei
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ABSTRACT

This study investigates whether or not Regulation Fair Disclosure (Reg FD) has decreased financial analysts’ information advantages over investors in processing the information contained in the cash flow components of earnings. The results of this study suggest that investors’ overall performance on utilizing the information contained in the cash flows component has improved subsequent to Reg FD, and that Reg FD appears to have dampened financial analysts’ information advantages over investors. However, our results also suggest that the information environment may be more “noisy” in the post-FD period, evidenced by increased analysts’ mis-weightings.

INTRODUCTION

This study examines whether or not the Regulation Fair Disclosure (hereafter, Reg FD) affects financial analysts’ and investors’ weightings of the cash components in forecasting annual earnings. Prior literature documents investors’ under- or over-reactions to certain public available information. Prior studies also show that financial analysts, as information intermediaries, are less biased than investors in processing accounting information. For example, Sloan (1996) demonstrates that operating cash flows are more persistent than accruals. Investors, however, fixate on earnings and fail to reflect the greater persistence of the cash flow component in forming their earnings expectations. Subsequently, several studies document that investors under-weight the persistence of operating cash flow and over-weight the accrual component of earnings, and that investors’ mis-weightings are not entirely driven by financial analysts’ earnings forecasts. Using financial analysts’ forecasts of earnings as empirical proxies for investors’ expectations of earnings, Bradshaw et al. (2001) find that the apparent investor bias is driven solely by the working capital component of the earnings accruals. Elgers et al. (2003) examine whether financial analysts’ forecasts of annual earnings reflect an over-weighting of working capital accruals that is consistent with the mis-weighting documented in Sloan (1996) and Bradshaw et al. (2001). They find that the over-weighting of working capital accruals in analysts’ earnings forecasts is less than one-third of the over-weighting by investors that is implicit in stock prices. Moreover, less than 40 percent of the delayed returns associated with working capital accruals can be attributed to subsequent errors in analysts’ annual earnings forecasts, for firms with less than median levels of analyst coverage. Their findings suggest that financial analysts are much less biased than investors in weighting working capital accruals, and that other securities market inefficiencies that are unrelated to financial analysts’ earnings forecasts underlie at least part of the accruals anomaly.

As distinct from the accrual-related anomaly, Dechow et al. (2008) investigate the persistence and pricing of the cash component of annual earnings. They decompose the cash component into three sub-components: (1) cash that is retained by the firm, (2) cash flows to or from equity holders as a result of equity financing, and (3) cash flows to or from debt holders as a result of debt financing. They demonstrate that the higher persistence of the cash component (relative to accruals) is entirely attributable to cash flows related to equity financing. However, investors fail to anticipate the lower persistence for cash retained by the firm relative to cash flows to/from equity holders and debt holders. Based upon the decomposition scheme developed in Dechow et al. (2008), Lo and Xu (2008) examine whether or not financial analysts contribute to investors’ mis-weighting of the cash flow component. They find that financial analysts’ weightings of the cash flow components are more closely aligned with the historical relations than are the corresponding weightings by investors, both in direction and in magnitude. Their findings document that financial analysts are less biased than investors in weighting the cash component of annual earnings.

Reg FD was approved by the Securities and Exchange Commission (SEC) on August 10, 2000 and became effective on October 23 of the same year. The intent of Reg FD is to reinforce the integrity of capital market by imposing higher transparency requirements on the voluntary disclosure practices of public companies. This regulation prohibits the selective disclosure of material information to preferred financial professionals (e.g., analysts and institutional shareholders). Companies with material information to disclose must now do so in a press release or conference call that is simultaneously open to all investors and general public. As expected, financial analysts expressed strong resistance to Reg FD. They argued that this change in information communication would affect their ability to operate effectively and that

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1 Operating cash flows are more persistent than accruals means that current-year operating cash flows have a stronger linear relation with subsequent-year earnings.
information communicated by issuers to the general public would be of lower quality.

Subsequent to the implementation of Reg FD, numerous studies have investigated the impact of Reg FD on the information environment of firms, capital market and financial analysts. For example, Sunder (2003), Eleswarapu et al. (2004), and Chiyachantana et al. (2004) show that Reg FD has been effective in decreasing the level of information asymmetry among equity investors. DeFusco et al. (2010) document that the information efficiency of stock prices has improved not only in the immediate aftermath of Reg FD, but also in later periods from 2002 to 2005. Findlay and Mathew (2006) examine the impact of Reg FD on financial analysts’ earnings forecast accuracy and find that analysts forecast accuracy declines overall after Reg FD. Moreover, analysts that are relatively less accurate (more accurate) prior to Reg FD improve (deteriorate) after the implementation of Reg FD. Collectively, these findings suggest that Reg FD has leveled the information playing field among different classes of capital market participants by prohibiting selective disclosure of material non-public information to privileged financial professionals. These studies examine the impact of Reg FD on investors/capital market and financial analysts separately. On the other hand, as described earlier, it has been documented that analysts are superior over the market in processing publicly disclosed financial information. The findings from these two bodies of research raise some logical questions: Does Reg FD improve (undermine) investors’ (analysts’) performance on information processing? Has “leveling the information playing field” decreased financial analysts’ superiority to investors in processing financial information?

The objective of this study is to address the above questions. Dechow et al. (2008) show the differential persistence among the three cash components of earnings as well as investors’ weightings of these components. Lo and Xu (2008) document that financial analysts are more effective than investors in recognizing the differential persistence of cash components. They find that analysts’ weightings of cash components are much closer to the historical weightings than those of investors, in both direction and magnitude. The sample periods of both Dechow et al. (2008) and Lo and Xu (2008), from 1950 to 2003 and from 1985 to 2004, respectively, include primarily the years prior to the passage of Reg FD. This study builds on their findings and attempts to answer a question: has the financial analysts’ superiority to investors in processing information contained in the cash flow components of earnings decreased subsequent to the implementation of Reg FD? Specifically, we examine investors’ and financial analysts’ weightings of the cash components of earnings in both the pre-FD and the post-FD periods, using the historical weightings as benchmarks. We find that investors’ weightings on cash flow components are closer to the historical weightings in the post-FD period. Moreover, in the post-FD period, the magnitude of investors’ mis-weightings of cash flow components has decreased, and investors’ weightings are more similar to those of analysts. Overall, the empirical results of this study suggest that Regulation Fair Disclosure appears to have dampened financial analysts’ information advantages over investors.

The remainder of the paper is structured as follows. Section 2 develops the hypotheses about the impact of Reg FD on investors’ and financial analysts’ weightings of the cash components of annual earnings. Section 3 explains the research design and empirical models. Section 4 presents the empirical results. Section 5 concludes.

**HYPOTHESES**

This paper addresses the research question: “does the Reg FD affect financial analysts’ information advantages in weighting the cash flow components of earnings?” To pursue this question, we first divide our sample into two periods – before Reg FD period and after Reg FD period. We then compare financial analysts’ and investors’ weightings of cash flow components within each sample period, using historical persistence estimate as a benchmark. Following the earnings decomposition approach in Dechow et al. (2008) and Lo and Xu (2008), we disaggregate annual earnings (E) into total accruals (ACCR), changes in cash (ΔCash), net cash distributions to equity holders (DISTQ), and net cash distributions to debt holders (DISTD):³

\[ E = \Delta \text{ACCR} + \Delta \text{Cash} + \Delta \text{DISTQ} + \Delta \text{DISTD} \]

In examining investors’ weightings of these cash flow components, Dechow et al. (2008) find that the higher persistence of the cash component of earnings is entirely due to net cash distributions to equity holders, and that investors overestimate the persistence of cash retained by the firms, although they correctly anticipate the relatively higher (lower) persistence of net cash distributed to equity (debt) holders. Their findings suggest that investors fail to fully recognize the differential persistence of the cash components. As information intermediaries, financial analysts presumably influence investors’ expectations. Prior studies in comparing the usage of accounting information by analysts and investors document that, in some contexts, financial analysts utilize financial information more effectively than investors do, and that market mispricing appears to reflect bias in investors’ earnings expectations that is more pronounced than any related bias in financial analysts’ forecasts.

Several possible reasons could explain financial analysts’ superiority in processing accounting information. One prominent explanation is that financial analysts have private access to non-public information. With the institution of Reg FD, however, companies are prohibited to selectively disclose material information to preferred financial professionals, which include analysts and institutional shareholders. Companies with material information to disclose must now do so in a press release or conference call that is simultaneously open to all

³ See Dechow et al. (2008), pp541-542 for detailed explanations of this decomposition of income. All earnings components variables in their study are scaled by average total assets.

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investors. The passage of Reg FD may have mitigated, if not removed, analysts’ superiority over investors in processing financial information. Prior empirical research that examines the impact of Reg FD has provided evidence that is consistent with this conjecture.

Sunder (2003), Eleswarapu et al. (2004), Brown et al (2004) and Cornett et al (2007) document that Reg FD has leveled the information playing field among different classes of investors by providing equal access to information from disclosing firms. With the leveled playing field in the post Reg FD period, previously disadvantaged investors now have access to information at the same time as analysts do. Recently, DeFusco et al. (2010) show that there is an improvement in the information efficiency of stock prices after Reg FD, and the improvement persists in later periods beyond the immediate aftermath of Reg FD. One plausible explanation for this improvement is that Reg FD enables all types of investors gain equal access to previously unavailable information, and hence makes them better able to process information than they did prior to Reg FD. Moreover, Findlay and Mathew (2006) show that, after Reg FD, financial analysts’ forecast accuracy declines overall. Bailey et al. (2003) document that analysts forecast dispersion increases subsequent to Reg FD. The evidence that analysts’ forecasts are less accurate and more dispersed after Reg FD suggests that financial analysts’ performance has declined, perhaps at least in part due to the loss of their privileged access to private information. The above evidence leads us to speculate that, in the post-FD period, investors can better assess the information contained in cash flow components, and financial analysts are less able to sustain their superiority over investors as they did before.

We address investors’ and financial analysts’ ability to process the information contained in cash components based upon two dimensions: the rankings as well as the weightings of the persistence of cash flow components. The rankings of cash components indicate whether or not investors and analysts directionally recognize the differential persistence of cash components. The weightings of cash components, on the other hand, indicate the magnitude of the persistence perceived by investors and analysts. We use the historical persistence of earnings components as the benchmark to make comparisons. According to the inferences derived from prior literature discussed above, we form the following hypotheses (in alternative form):

H1: The rankings of the persistence of cash flow components by investors are closer to their historical rankings in the post-FD period.

H2: The weightings of the persistence of cash flow components by investors are closer to their historical weightings in the post-FD period.

H3: The differences in the mis-weightings of cash flow components between investors and financial analysts are smaller in the post-FD period.

**RESEARCH DESIGN**

**Sample Selection and Variable Definitions**

Our analyses use December fiscal-year-end firm-years from the intersection of COMPUSTAT Annual database (including both active and inactive firms), CRSP Monthly Return database and I/B/E/S Summary database. In order to be included in the sample, each observation must include all the following variables (firm specific subscripts are omitted). The definitions of earnings and earnings components are the same as in Dechow et al. (2008) and Lo and Xu (2008).

\[ E_{t+1} = \text{Annual income before extraordinary items and discontinued operations available for common stockholders for year } t+1. \]

\[ ACCR_t = \text{Total annual accruals for year } t. \]

\[ = \Delta \text{Non-Cash Assets} - \Delta \text{Non-Debt Liabilities} \]

\[ \text{Where Non-Cash Assets} = \text{Total assets} - \text{Cash \\ & \text{equivalents} \]

\[ \text{Non-Debt Liabilities} = \text{Total liabilities} - \text{Debt} \]

\[ \Delta CASH_t = \text{Change in cash for year } t. \text{ Cash is defined as} \]

\[ \text{cash and equivalents.} \]

\[ DIST^{90}_t = \text{Cash distributions to equity holders for year } t. \]

\[ = E_t - \text{Change in equity for year } t \]

\[ = E_t - (\Delta \text{Total Assets} - \Delta \text{Total Liabilities}) \text{ for year } t. \]

\[ DIST^{10}_t = \text{Cash distributions to debt holders for year } t. \]

\[ = \text{Reduction in debt for year } t \]

\[ = \text{Reduction in long-term debt + Reduction in short-term debt, for year } t. \]

\[ SAR_{t+1} = \text{Size-adjusted security return, measured as the} \]

\[ \text{realized market return in year } t+1 (\text{May 1 year } t+1 \text{ through April 30, year } t+2), \text{less the} \]

\[ \text{corresponding median return in the same} \]

\[ \text{market capitalization decile at the start of year } t+1. \]

\[ FAF_{t+1} = \text{I/B/E/S median (consensus) analyst forecast of} \]

\[ \text{annual earnings, reported in May of the} \]

\[ \text{following year, multiplied by shares outstanding and scaled by average total assets.} \]

\[ Size_t = \text{Natural log of market value of equity at the end of} \]

\[ \text{year } t. \]

\[ M/B_t = \text{Market value of equity divided by book value of} \]

\[ \text{equity at the end of year } t. \]

\[ P/E_t = \text{Market value of equity divided by income before} \]

\[ \text{extraordinary items and discontinued operations.} \]

\[ Lev_t = \text{Total liabilities divided by total assets at the end of} \]

\[ \text{year } t. \]

\[ Int_t = \text{Average federal primary discount rates of year } t. \]

In order to ensure that earnings are announced before the start of the cumulating period of size-adjusted securities returns, we only keep observations with earnings...
announcement dates earlier than May 1 of year t+1. Because the start of the cumulating period for size-adjusted securities returns, and hence the date at which the implicit securities market earnings expectations are measured, is May 1 of year t+1, we use the May consensus forecasts to ensure comparability between analysts’ and market’s implicit earnings expectations. All earnings and components variables are scaled by average total assets, consistent with Dechow et al. (2008) and Lo and Xu (2008). The last five variables above are included in the study as control variables. For simplicity purpose, we do not report results related to these control variables in the empirical analysis section.

I/B/E/S analyst data was sparse prior to year 1985. For this reason, our sample period starts in 1985 in order to minimize self selection bias. To mitigate the potential effects of outliers on our analyses, we winorize the extreme cases for the asset-scaled earnings components variables at +1 and -1 in each year, as used in Dechow et al. (2008) and Lo and Xu (2008). In addition, we winorize the extreme cases for the asset-scaled analysts’ forecasts of earnings (FAF) at +4 and -4 in each year. We define the Pre-FD period as 1985-1999 and the Post-FD period as 2001-2008. To ensure cleaner comparisons between the Pre-FD and the Post-FD periods, we exclude the year 2000 from our sample because Reg FD took effect in 2000. Our final sample contains 39,081 firm-years over the period 1985-2008, with 20,032 firm-years in the Pre-FD period and 19,049 firm-years in the Post-FD period.

Empirical Models

The empirical models used in this study are the same as in Lo and Xu (2008). Their paper documents that financial analysts are superior to investors in processing information contained in the cash components of earnings, while this study examines whether or not Reg FD affects such superiority of financial analysts. For this purpose, we will compare the results of the empirical models between the Pre-FD and the Post-FD periods.

To obtain the historical persistence of earnings components as a benchmark, we relate realized earnings to the earnings components from the previous year and estimate the following model:

$$E_{i,t} = \alpha_0 + \alpha_1 \text{ACCR}_i + \alpha_2 \text{CASH}_i + \alpha_3 \text{DIST}^p_i + \mu_{i,t}$$  

(1)

The parameter estimates for the three cash components of earnings (i.e., $\hat{\alpha}_i$, i = 2, 3 and 4) indicate the historical persistence or weightings of these cash components. These historical weightings are the benchmarks against which the investors’ and financial analysts’ weightings are compared.

To examine investors’ weightings of these prior-year earnings components that are implicit in securities prices, we follow the convention to regress unexpected returns on unexpected earnings. Because unexpected earnings are the excess of realized earnings, $E_{i,t}$, over expected earnings, we use prior-year earnings components as a base for investors’ earnings expectations and derive the following regression:

$$SAR_{i,t+1} = \delta_0 + \delta_1 (E_{i,t+1} - \gamma_0 \text{ACCR}_i - \gamma_1 \Delta\text{CASH}_i - \gamma_2 \text{DIST}^p_i - \gamma_3 \text{DIST}^q_i) + \mu_{i,t+1}$$

(2)

The investor’s weightings of earnings components are measured by $\hat{\gamma}_i$ (i = 1, 2, 3 and 4). The above method was developed in Mishkin’s (1983) assessment of rationality in bond pricing and subsequently adapted by Sloan (1996). This econometric approach, i.e. simultaneous non-linear least squares regression, allows us to simultaneously estimate the investors’ weightings of the accrual and cash components of earnings indicated in expression (2). Please see Elgers et al (2003) for detailed explanation of this method.

To examine the weightings of the prior-year earnings components by financial analysts, we regress financial analysts’ earnings forecasts on the accrual and cash components of earnings from the previous year and estimate the following model:

$$\text{FAF}_{i,t} = \beta_0 + \beta_1 \text{ACCR}_i + \beta_2 \Delta\text{CASH}_i + \beta_3 \text{DIST}^p_i + \beta_4 \text{DIST}^q_i + \mu_{i,t}$$

(3)

This model is parallel to the historical relation in expression (1). The parameter estimates $\hat{\beta}_i$ (i = 1, 2, 3 and 4) indicate analysts’ weightings of prior-year earnings components implied in their earnings forecasts. To test our hypotheses, we compare three sets of weightings of the cash components between the Pre-FD and the Post-FD periods, i.e., the historical persistence (the coefficient estimates of $\hat{\alpha}_2$, $\hat{\alpha}_3$, and $\hat{\alpha}_4$ in expression (1)), the investors’ weightings (the coefficient estimates of $\hat{\gamma}_2$, $\hat{\gamma}_3$, and $\hat{\gamma}_4$ in expression (2)), and the analysts’ weightings (the coefficient estimates of $\hat{\beta}_2$, $\hat{\beta}_3$, and $\hat{\beta}_4$ in expression (3)) both in direction and in magnitude.

Specifically, to test hypothesis 1, we examine the rankings of the cash flow components by investors from expression (2), and compare their rankings to the historical rankings observed from expression (1) in both the Pre-FD and the Post-FD periods. We expect the investors’ rankings from expression (2) (i.e. $\hat{\gamma}_2$, $\hat{\gamma}_3$, and $\hat{\gamma}_4$) are closer to historical rankings from expression (1) (i.e. $\hat{\alpha}_2$, $\hat{\alpha}_3$, and $\hat{\alpha}_4$) in the Post-FD period.

To test hypothesis 2, we formally contrast investors’ weightings to historical weightings separately for the three cash flow components in the Pre- and Post-FD periods. We expect the difference between the investors’ and historical weightings on the cash components (i.e. $\hat{\alpha}_2 - \gamma_2$, $\hat{\alpha}_3 - \gamma_3$, and $\hat{\alpha}_4 - \gamma_4$) are reduced in the Post-FD period.

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To test hypothesis 3, we formally contrast investors’ weightings to analysts’ weightings for the three cash components in the Pre- and Post–FD periods. We expect the difference between investors’ and analysts’ weightings on the cash components (i.e. $\gamma_2 - \beta_2$, $\gamma_3 - \beta_3$, and $\gamma_4 - \beta_4$) is reduced in the Post–FD period.

In addition, we have included five control variables in the above three empirical models, Size, M/B, Int, P/E, and Lev, as defined in Section 3.1. Because this study compares results between two different periods of time, changes in firm-specific factors and overall market condition may drive the results. These control variables are included to eliminate this competing explanation. For example, Int (average federal discount rate for a given year) is included to control for the change in overall market condition. By controlling for firm-specific factors and overall market condition, we can attribute the results to the effect of Reg FD. In addition, Kraft et al. (2005) has shown that the Mishkin (1983) approach requires difficult distributional assumptions including multivariate normality of the regressors, the stability of the covariance relations over the years used in pooled estimation, the absence of omitted variables in the pricing equation, and the absence of cross-correlations in the regression residuals. Yu (2008) shows that these difficulties are substantially mitigated by the inclusion of firm size and market-to-book ratios as control variables. Thus the inclusion of Size and M/B in our empirical models mitigates these concerns about the Mishkin framework.

**EMPIRICAL RESULTS**

**Descriptive Statistics**

Table 1 presents descriptive statistics as well as Pearson correlations for the entire sample period. The results show positive means for $ACCR_t$ and $\Delta CASH_t$, indicating that our sample firms have been growing during the sample years. Untabulated results for the Pre-FD and Post-FD periods, however, indicate that both $ACCR_t$ and $E_t$ have decreased from the Pre- to the Post-FD period. These results suggest that the growth has slowed in the Post-FD period, which is consistent with the economic turbulence related to the burst of the tech bubble in the early 2000’s and recent financial crisis. Negative means for $DIST^{EQ}_{t+1}$ and $DIST^0_t$ indicate that the amount of capital raised by those firms from their capital holders is more than the amounts distributed to capital holders. In addition, the cash raised from equity holders (debt holders) increases (decreases) from the Pre-FD to the Post-FD period, indicating that firms increase their reliance on equity financing subsequent to the year 2000. The standard deviations of individual components of earnings show that each component, i.e. $ACCR_t$, $\Delta CASH_t$, $DIST^{EQ}_{t+1}$ and $DIST^0_t$, represents an important source of the variation in earnings.

Pearson correlations reveal empirical regularities documented in prior research. Size-adjusted returns, $SAR_{t+1}$, and prior-year accruals, $ACCR_t$, are negatively correlated, consistent with the lagged security price adjustments to accruals reported in Sloan (1996), Bradshaw et al. (2001) and Elgers et al. (2003). The correlations between accruals, $ACCR_t$ and cash distributed to equity holders, $DIST^{EQ}_{t+1}$, as well as to debt holders, $DIST^0_t$, are negative, consistent with the role of accruals in mitigating timing problems in cash flow measures of earnings (Dechow 1994). $\Delta CASH_t$ and $DIST^{EQ}_{t+1}$ are also negatively correlated, since cash distributions to equity holders consume a firm’s free cash.

**Historical, Investors’ and Analysts’ Weightings of Prior-Year Cash Components: Pre- and Post-FD Periods**

Table 2. Panel A presents historical weightings of the cash components in the Pre-FD and the Post-FD periods. Consistent with Dechow et al. (2008) and Lo and Xu (2008), cash distributed to equity holders, $DIST^{EQ}_{t+1}$, is the most persistent among the three cash components, 0.661 and 0.793 respectively, in both the Pre- and Post-FD periods. In the Pre-FD period, the historical weightings on $\Delta CASH_t$ (0.543) and $DIST^0_t$ (0.551) are statistically indistinguishable. Yet in the post-FD period, the historical weighting on $DIST^0_t$ (0.661) is higher than that on $\Delta CASH_t$, (0.614). In both the Pre- and Post-FD periods, coefficients of $DIST^0_t$ and $\Delta CASH_t$ are similar to that of $ACCR_t$, indicating that the higher persistence of cash flows vs. accruals is driven by cash distributed to equity holders. Overall, it shows that the historical ranking of the cash components is highest for $DIST^{EQ}_{t+1}$.

Table 2, Panel B presents investors’ implicit weightings of the cash components in the Pre- and Post-FD periods. In the Pre-FD period, investors appear to recognize that $DIST^{EQ}_{t+1}$ is more persistent than $\Delta CASH_t$. However, investors fail to recognize that $DIST^{EQ}_{t+1}$ is the most persistent among the three cash components. Investors’ weighting on $DIST^{EQ}_{t+1}$ (1.208) is statistically indifferent from their weighting on $DIST^0_t$ (1.156), with a $p$-value of 0.271. This evidence suggests that investors’ rankings of the cash components are inconsistent with the historical rankings reported in Panel A, which ranks $DIST^{EQ}_{t+1}$ the highest. In the Post-FD period, investors appear to weight $\Delta CASH_t$, the highest (0.690), again inconsistent with the historical ranking. These results do not support our first hypothesis, which states that the rankings of the persistence of cash flow components by investors are closer to their historical rankings in the post-FD period. Instead the results show that the investors fail to reflect the highest ranking of $DIST^{EQ}_{t+1}$ in both the Pre- and Post-FD periods.

Table 2 Panel C presents analysts’ weightings of the cash components in the Pre- and Post-FD periods. In both periods, analysts correctly recognize the highest persistence of $DIST^{EQ}_{t+1}$ among the three cash components. The results suggest that analysts are more sophisticated than investors in evaluating the persistence of cash components, even in the Post-FD period. The passage of Reg FD does not seem to affect financial analysts’ better
performance than investors in ranking the persistence among the three cash components.

The tests above focus on the change in directional comparisons (i.e., rankings) of the weightings of the cash components implicit in historical, investors’ and analysts’ relations, between the Pre- and Post-FD periods. To test our next two hypotheses, the following section focuses on the change in the magnitude of the weighting differences across these relations between the Pre- and Post-FD periods.

Comparisons of Weightings of Prior-Year Cash Components: Pre- and Post-FD Periods

Table 3, Panels A and B report three sets of formal contrasts of the weighting differences for the cash components reported in Table 2 for the Pre- and Post-FD periods. First, the historical relations of the cash components to subsequent-period realized earnings (in Table 2 Panel A) are compared to investors’ weightings (in Table 2 Panel B), to assess the magnitude of investors’ mis-weighting of the three cash components. Second, the historical relations (in Table 2 Panel A) are compared to financial analysts’ weightings (in Table 2 Panel C), to evaluate the magnitude of analysts’ mis-weighting of the cash components. Last, the investors’ weightings (in Table 2 Panel B) are compared to financial analysts’ weightings (in Table 2 Panel C) to address to what extent the analysts’ bias contributes to the investors’ bias in weighting these cash components. We will use the change in these comparisons between the Pre- and Post-FD periods to test our second and third hypotheses. Table 3 Panel C presents these changes in contrasts of weightings from the Pre- to Post-FD periods.

Table 3 Panel A shows that, when comparing investors’ and historical weightings, investors over-estimate all components of earnings in the Pre-FD period. The over-weightings are 0.561, 0.547 and 0.605, on \( \Delta \text{Cash}_t \), \( \text{DIST}^{EQ}_t \), and \( \text{DIST}^{EQ}_t \), respectively. Table 3 Panel B shows that investors overweight only \( \Delta \text{Cash}_t \) (0.076) but underweight both \( \text{DIST}^{EQ}_t \) (0.251) and \( \text{DIST}^{EQ}_t \) (0.200) in the Post-FD period. Table 3 Panel C compares the mis-weightings of investors on the earnings components between the Pre- and Post-FD periods. Note that we compare the magnitude of mis-weightings, regardless of over- or under-weightings. For example, investors’ mis-weighting on \( \Delta \text{Cash}_t \), is 0.561 in the Pre-FD period and the magnitude of mis-weighting declines to 0.076 in the Post-FD period. The change (or decrease) in the mis-weighting is 0.485 and significant at 1%. The investors’ mis-weightings on \( \text{DIST}^{EQ}_t \), and \( \text{DIST}^{EQ}_t \) decrease by 0.296 and 0.405, respectively, both significant at 1%. These results suggest that the magnitudes of investors’ weightings on the cash components are closer to the historical weightings in the Post-FD period, consistent with our second hypothesis.

Table 3 also compares analysts’ and investors’ weightings in the Pre- and Post-FD periods. Table 3 Panel A shows that investors’ weightings on all of the three cash components are higher than analysts’ weightings in the Pre-FD period. Table 3 Panel B shows that, in the Post-FD period, analysts’ weightings are higher than investors’ for all three cash components, but their weightings are closer to each other. For example, the difference between investors’ and analysts’ weighting on \( \Delta \text{Cash}_t \) is 0.597 in the Pre-FD period, and it decreases sharply to -0.007 in the Post-FD period. The difference of the weightings on \( \text{DIST}^{EQ}_t (\text{DIST}^{EQ}_t) \) is 0.610 (0.638) in the Pre-FD period, and it declines by about one-half to -0.331 (-0.246). Table 3 Panel C tests the change in the magnitude of the weighting contrasts and shows that these decreases in the weighting differences between the Pre- and Post-FD periods are significant at 1%, for all three cash components. These results are consistent with our third hypothesis that investors’ weightings on the cash components are closer to analysts’ in the Post-FD period. It further indicates that Reg-FD reduces non-public information available to analysts, creating a more leveled playing field for market participants. More similarity between investors’ and analysts’ weightings is consistent with our hypothesis that the superiority of financial analysts is less prominent in the Post-FD period.

There are a few more noteworthy observations related to Table 3. First, Table 3 Panel A shows analysts seem to underweight all three cash components. In addition, analysts’ mis-weightings on the cash components are much smaller than investors’ mis-weightings and seem to be economically insignificant (0.036/0.543=6.6% for \( \Delta \text{Cash}_t \), 0.063/0.661=9.5% for \( \text{DIST}^{EQ}_t \), and 0.033/0.551=6% for \( \text{DIST}^{EQ}_t \)). This is consistent with the findings from prior literature that analysts are more sophisticated than investors in processing information. Second, as previously discussed, even though investors’ mis-weightings on the cash components have decreased and investors’ weightings are closer to historical in the Post-FD period, analysts’ mis-weightings, in general, continue to be smaller than investors’ based on Table 3 Panel B. For example, analysts’ mis-weighting on \( \text{DIST}^{EQ}_t \) (\( \text{DIST}^{EQ}_t \)) is -0.080 (-0.046), much less than investors’ mis-weighting of 0.251 (0.200). The only exception is that analysts’ mis-weighting on \( \Delta \text{Cash}_t \) (-0.076) is slightly higher than investors’ (-0.076) although statistically insignificant. This indicates that even though investors have improved in their ability to process information in the cash components subsequent to Reg FD, analysts remain to be more superior in processing such information. This further suggests that analysts’ superiority in processing information is not derived only from private information, but also from their expertise, years of experience and etc. Lastly, Table 3 also shows that analysts’ mis-weightings on the cash components have increased from the Pre- to Post-FD periods. For example, analysts’ mis-weighting on \( \Delta \text{Cash}_t \) is 0.036 in the Pre-FD period and increases to 0.083 in the Post-FD period. The same pattern holds for \( \text{DIST}^{EQ}_t \) and \( \text{DIST}^{EQ}_t \). This may indicate that even though the playing field is more leveled in the Post-FD period, the information environment may be more “noisy” and hence analysts’ mis-weightings become more severe in the Post-FD period. To some extent, the evidence is consistent with the finding that financial analyst forecast dispersion increases after Reg FD (Bailey, et al. 2003), and the speculation that companies tend to issue less publicly
available information with lower quality after the institution of Reg FD.\(^5\)

Overall, the results in Table 3 support our second and third hypotheses that investors’ mis-weightings of the cash components have decreased and investors’ weightings are more similar to analysts’ in the Post-FD period. These results reflect the impact of Reg FD by eliminating selective disclosure among different classes of investors in the market.

To present a visual summary of the above comparisons, Figure 1 depicts the weightings for \(ACCR_t\), \(\Delta CASH_t\), \(DIST_t^{EQ}\) and \(DIST_t^{D}\) based upon the historical, financial analysts’ and investors’ relations (in Table 2) for the Pre- and Post-FD periods. Note that analysts’ weightings on all components closely follow investors’ weightings both in direction and in magnitude in both the Pre- and Post-FD periods. This shows that analysts are still more superior in processing information in cash components even after the elimination of selective disclosure by Reg FD. Second, investors’ weightings are closer to both historical and analysts’ weightings in the Post-FD period, supporting the second and third hypotheses. These suggest that the playing field is more leveled for market participants after the passage of Reg FD.

**SUMMARY AND CONCLUSIONS**

This study investigates whether or not Regulation Fair Disclosure has decreased financial analysts’ information advantages over investors in processing the information contained in cash flow components of earnings. We examine the ranking as well as the weightings of the cash flow components by financial analysts and investors in both Pre- and Post-FD periods. We also examine the magnitudes of mis-weightings by both analysts and investors in both Pre- and Post-FD periods.

The empirical results indicate that investors’ weightings on cash flow components are closer to the historical weightings of these components in the Post-FD period. Moreover, the magnitude of investors’ mis-weightings of cash flow components has decreased in the Post-FD period, and investors’ weightings are more similar to those of analysts’ in the Post-FD period. Investors’ rankings of the persistence of cash flow components, however, do not show significant improvement in the Post-FD period. Specifically, investors fail to reflect the highest persistence of cash distribution made to equity holders. Collectively, the results of this study suggest that investors’ overall performance on utilizing the information contained in the cash flows component has improved subsequent to Regulation Fair Disclosure, and that Regulation Fair Disclosure appears to have dampened financial analysts’ information advantages over investors. However, our results also suggest that the information environment may be more “noisy” in the post-FD period, evidenced by increased analysts’ mis-weightings.

**REFERENCES**


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\(^5\) The Securities Industry Association (SIA) conducted a survey by interviewing 30 financial analysts in 2001 (SIA 2001). Of the analysts interviewed, 47 percent indicated that companies engaged in less communication and 72 percent indicated that information communicated by disclosing firms to the public was of lower quality in the Post-FD period.


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**TABLE 1**

Descriptive Statistics: All cases (41,312 Firm-years, 1985-2008)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
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</thead>
<tbody>
<tr>
<td>$E_t$</td>
<td>0.019</td>
<td>0.159</td>
</tr>
<tr>
<td>$ACCR_t$</td>
<td>0.082</td>
<td>0.195</td>
</tr>
<tr>
<td>$\Delta Cash_t$</td>
<td>0.040</td>
<td>0.190</td>
</tr>
<tr>
<td>$DIST_{EQ}$</td>
<td>-0.073</td>
<td>0.241</td>
</tr>
<tr>
<td>$DIST_{DO}$</td>
<td>-0.029</td>
<td>0.144</td>
</tr>
<tr>
<td>$SAR_{t+1}$</td>
<td>0.072</td>
<td>0.615</td>
</tr>
<tr>
<td>$FAF_{t+1}$</td>
<td>0.028</td>
<td>0.169</td>
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</table>

<table>
<thead>
<tr>
<th>Pearson Correlations</th>
<th>$ACCR_t$</th>
<th>$\Delta Cash_t$</th>
<th>$DIST_{EQ}$</th>
<th>$DIST_{DO}$</th>
<th>$SAR_{t+1}$</th>
<th>$FAF_{t+1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E_t$</td>
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<td>0.204</td>
<td>0.250</td>
<td>0.115</td>
<td>-0.040</td>
<td>0.646</td>
</tr>
<tr>
<td>$ACCR_t$</td>
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<td>0.000</td>
<td>-0.348</td>
<td>-0.533</td>
<td>-0.065</td>
<td>0.087</td>
</tr>
<tr>
<td>$\Delta Cash_t$</td>
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<td>-0.645</td>
<td>-0.013</td>
<td>-0.061</td>
<td>-0.019</td>
<td></td>
</tr>
<tr>
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<td>0.057</td>
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<td>$DIST_{DO}$</td>
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<td>0.042</td>
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<td>$SAR_{t+1}$</td>
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<td>$FAF_{t+1}$</td>
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<td></td>
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</tbody>
</table>

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*The 11th International DSI and the 16th APDSI Joint Meeting, Taipei, Taiwan, July 12 – 16, 2011, pp.1-11*
TABLE 2
Historical, Investors’ and Financial Analysts’ Weightings of the Accrual and Cash Flow Components of Earnings
Pre-FD Period: 20,032 firm-years, 1985-1999
Post-FD Period: 19,049 firm-years, 2001-2008

Panel A: Historical Relations of Realized Earnings to the Accrual and Cash Flow Components of Earnings

\[ E_{t+1} = \alpha_0 + \alpha_1 \text{ACCR}_t + \alpha_2 \Delta \text{CASH}_t + \alpha_3 \text{DIST}_t^{EQ} + \alpha_4 \text{DIST}_t^D + \alpha_5 \text{Size}_t + \alpha_6 M / B_t + \alpha_7 \text{Int}_t + \alpha_8 P / E_t + \alpha_9 \text{Lev}_t + \mu_{t+1} \]

<table>
<thead>
<tr>
<th></th>
<th>Pre-FD Period</th>
<th></th>
<th>Post-FD Period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>P-Value</td>
<td>Coefficient</td>
</tr>
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<td>\text{ACCR}_t</td>
<td>0.550</td>
<td>(0.000)</td>
<td>0.628</td>
</tr>
<tr>
<td>\Delta \text{Cash}_t</td>
<td>0.543</td>
<td>(0.000)</td>
<td>0.614</td>
</tr>
<tr>
<td>\text{DIST}_t^{EQ}</td>
<td>0.661</td>
<td>(0.000)</td>
<td>0.793</td>
</tr>
<tr>
<td>\text{DIST}_t^D</td>
<td>0.551</td>
<td>(0.000)</td>
<td>0.661</td>
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</table>

Comparison of Weightings

\[ \alpha_2 = \alpha_3 \]
\[ \alpha_5 = \alpha_4 \]
\[ \alpha_8 = \alpha_9 \]

Panel B: Investors’ Weightings of the Accrual and Cash Flow Components of Prior-Year Earnings

\[ \text{SAR}_{t+1} = \delta_0 + \delta_1 (E_{t+1} - \gamma_0 \text{ACCR}_t - \gamma_2 \Delta \text{CASH}_t - \gamma_3 \text{DIST}_t^{EQ} - \gamma_4 \text{DIST}_t^D) + \delta_2 \text{Size}_t + \delta_3 M / B_t + \delta_4 \text{Int}_t + \delta_5 P / E_t + \delta_6 \text{Lev}_t + \mu_{t+1} \]

<table>
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<tr>
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<th>Pre-FD Period</th>
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<th>Post-FD Period</th>
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</thead>
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<tr>
<td></td>
<td>Coefficient</td>
<td>P-Value</td>
<td>Coefficient</td>
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<tr>
<td>\text{ACCR}_t</td>
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<td>0.591</td>
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<tr>
<td>\Delta \text{Cash}_t</td>
<td>1.104</td>
<td>(0.000)</td>
<td>0.690</td>
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<tr>
<td>\text{DIST}_t^{EQ}</td>
<td>1.208</td>
<td>(0.000)</td>
<td>0.542</td>
</tr>
<tr>
<td>\text{DIST}_t^D</td>
<td>1.156</td>
<td>(0.000)</td>
<td>0.461</td>
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</table>

Comparison of Weightings

\[ \gamma_2 = \gamma_3 \]
\[ \gamma_5 = \gamma_4 \]
\[ \gamma_8 = \gamma_9 \]


\[ \text{FAF}_{t+1} = \beta_0 + \beta_1 \text{ACCR}_t + \beta_2 \Delta \text{CASH}_t + \beta_3 \text{DIST}_t^{EQ} + \beta_4 \text{DIST}_t^D + \beta_5 \text{Size}_t + \beta_6 M / B_t + \beta_7 \text{Int}_t + \alpha_8 P / E_t + \alpha_9 \text{Lev}_t + \mu_{t+1} \]

<table>
<thead>
<tr>
<th></th>
<th>Pre-FD Period</th>
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<th>Post-FD Period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>P-Value</td>
<td>Coefficient</td>
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<tr>
<td>\Delta \text{Cash}_t</td>
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Comparison of Weightings

\[ \beta_2 = \beta_3 \]
\[ \beta_5 = \beta_4 \]
\[ \beta_8 = \beta_9 \]
TABLE 3
Comparisons of Historical, Investors’ and Financial Analysts’ Weightings of the Cash Components of Earnings:
Pre- and Post-FD Periods

Panel A: Pre-FD Period (20,032 Firm-years, 1985-1999)

<table>
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<th>Contrasts of Weightings(^{(a)})</th>
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<tr>
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<td>Historical vs. Investors</td>
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<td>Weightings</td>
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<tr>
<td>(ACCR_t)</td>
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<tr>
<td>(DIST_{EQ})</td>
<td>0.661</td>
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<td></td>
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<tr>
<td></td>
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<tr>
<td>(DIST_{EQ})</td>
<td>0.551</td>
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</table>

Panel B: Post-FD Period (19,049 Firm-years, 2001-2008)

<table>
<thead>
<tr>
<th>Weightings Reported in Table 2</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Historical vs. Investors</td>
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<tr>
<td>Weightings</td>
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<tr>
<td>(ACCR_t)</td>
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<td></td>
<td></td>
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<tr>
<td>(DIST_{EQ})</td>
<td>0.661</td>
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### Panel C: Changes in Contrasts of Weightings from the Pre- to Post-FD Periods

<table>
<thead>
<tr>
<th></th>
<th>Historical vs. Investors</th>
<th>Historical vs. Analysts</th>
<th>Analysts vs. Investors</th>
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<tbody>
<tr>
<td></td>
<td>Pre-FD</td>
<td>Post-FD</td>
<td>Changes</td>
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<tr>
<td>$ACCR_t$</td>
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<tr>
<td>Difference</td>
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<td>0.037</td>
<td>0.802</td>
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<td>Likelihood Ratio</td>
<td>160.15</td>
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<td></td>
</tr>
<tr>
<td>(p-value)</td>
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<td></td>
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</tr>
<tr>
<td>$\Delta Cash$</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>-0.561</td>
<td>-0.076</td>
<td>0.485</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
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<td>(p-value)</td>
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<td></td>
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<tr>
<td>$DIST_{EQ}^t$</td>
<td></td>
<td></td>
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<tr>
<td>Difference</td>
<td>-0.547</td>
<td>0.251</td>
<td>0.296</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>26.31</td>
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<td></td>
</tr>
<tr>
<td>(p-value)</td>
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<td></td>
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</tr>
<tr>
<td>$DIST_{EQ}^t$</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>-0.605</td>
<td>0.200</td>
<td>0.405</td>
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<tr>
<td>Likelihood Ratio</td>
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<td>(p-value)</td>
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The Role of Resources and Capabilities in Global Sourcing: An Empirical Study Using Structural Equation Modeling

Martin Lockstrom, China Europe International Business School, China, mlockstrom@ceibs.edu

Abstract

This study empirically investigates how firm-specific capabilities and resources acquired through global sourcing activities affect process performance. The underlying research model was based on the resource-based view of the firm. In order to test the model, an empirical study was conducted through structured telephone interviews with Chief Procurement Officers and Purchasing Managers of 200 large-sized companies in five European countries. The results showed that process performance was strongly influenced by the level of external resources in control, which in turn were very strongly related to the extent of global sourcing capabilities of the firm. The overall conclusion is that global sourcing capabilities help firms getting access to a larger resource pool, which in turn affects performance in terms of effectiveness and efficiency positively.

Keywords: Global Purchasing, Strategy Development, Supplier Management, Factor Analysis, Structural Equation Modeling

I. Introduction

Globalization has induced immense competition in most industries. Moreover, firms competing in mature markets have experienced increasing difficulties to grow revenues in their home markets, especially in the aftermath of the recent global financial crisis. As a result, firms are increasingly focusing on cost reduction as a means for increasing shareholder value. As indicated by Monczka [1], offering low product prices as a result of being a low-cost producer is one of the most important competitive advantages today. However, firms with strategies focusing on differentiation also benefit from low cost since freed-up capital can instead be spent on more value adding activities. Furthermore, cost savings translate directly dollar by dollar to the bottom line result, making it the most effective means for improving corporate profitability [2].

In order to reduce costs and thus satisfying internal customer demand [3-4], an important objective of the corporate supply function is to source goods and services in a way that yields reductions in total cost while delivering adequate quality. The strategic importance of this task has increased significantly over the last few years, as manufacturers increasingly rely on contract manufacturing as a means to reduce production costs [5-6], especially as the bargaining power of contract manufacturers have grown steadily [7]. One of the most effective ways to achieve cost-saving targets is to source from countries at a global level, with the objective to achieve total cost reduction and less focus on purchase price [8], so called global sourcing [1, 9-11].

Earlier research suggests that global sourcing is a crucial task that needs to be planned and executed with great care. Despite anecdotal evidence of vast cost-savings opportunities, a company can easily end up with increased instead of decreased total costs if not doing global sourcing operations properly as transportation and logistics costs can comprise more than 30 percent of total landed cost [12]. Due to the many challenges imposed by globalization, there are numerous challenges and obstacles to overcome, for example cultural barriers, fluctuating currencies, increased distances for travel and transportation, political instability among others [13]. The question is not just which countries are attractive for sourcing in order to obtain reduced purchase prices, but rather which supplier that can deliver a certain type of goods or service at adequate quality to the lowest possible total cost, not only today, but over an extended period of time. As will be further elaborated in the next section, earlier research has primarily been focused on external market conditions, often omitting the role of the focal firm and its interaction with the external environment. Having said that, this paper aims at answering the following questions:

1. How can global sourcing performance ideally be conceptualized?
2. What are the antecedents to global sourcing performance?
3. What particular roles do capabilities and resources play in this context?

II. Conceptual Framework and Hypotheses

Over the last two decades, a rich body of research on global sourcing has emerged. Most of this research has either focused on the nature of the supplies sourced by applying transaction cost theory (TCT) [14-16] or situational factors as motivation for global sourcing [17]. However, less attention has been paid to the role of resources as a source of competitive advantage in a global environment. Hence, from a scientific perspective, the findings of the research will provide a novel and different perspective of global sourcing, compared to the dominating TCT-based research on global sourcing done during the 1990s and early 2000s.

By applying resource-based view (RBV) as a theoretical lens, it is interesting to examine the driving forces behind global sourcing strategies where companies are seeking new opportunities in overseas locations. According to RBV, global sourcing can be seen as a way of increasing the available resource pool to gain comparative advantage [18-19], and in turn gain competitive advantage, as firms expand their sourcing markets into new geographic regions. Such resources have two characteristics: they are (i) external to the firm and (ii) imperfectly mobile. (i) implies that the resources are not in full control of the firm, but can be at least partially controlled through management decisions. An example is a joint venture with a manufacturing firm or an exclusive strategic relationship with an overseas supplier [20]. (ii) implies that local presence is necessary to some extent in order to take advantage of the resource, since it
cannot be moved to the home country of the buying firm. Such resources are referred to as external resources, as they are located outside the firm’s boundaries. In contrast, an example of an internal resource could be effective deployment of Internet-based purchasing systems [21].

As a consequence, one of the key objectives of global sourcing is hence to acquire such external resources possessed by suppliers, and convert them to internal resources where they can generate competitive advantage [22]. Another goal is also to integrate and coordinate internal customer demand depending on category and market uncertainty as well as internal dependencies among purchasing offices [23]. In a similar fashion, Terpend et al. [24, p. 28] claims that the value derived from buyer-supplier relationships include global sourcing improved operational performance, better integration, supplier capabilities and financial improvement, all of which global sourcing practices can help enhancing. Srivistava et al. [25] suggests that many key resources arise from the firm’s interaction with the external environment. This notion is also supported by Dyer and Singh [26] who claim that “a firm’s critical resources may span firm boundaries and may be embedded in inter-firm resources and routines”. In particular, “cooperative competencies” are becoming increasingly important as value chains become more and more fragmented, with increasing dependency on suppliers for creation of customer value [5, 27-31]. Increased access to suppliers can also help creating a strong market position of the firm, ultimately generating competitive advantage [32].

A Delphi study conducted by Ogden et al. [33] indicated that leveraging supplier capabilities and improving supplier relationship were key strategic issues among purchasing managers. Based on the discussion above, it is plausible to believe that firms that possess a high level of external resources through global sourcing also have higher performance.

However, there are several difficulties in trying to operationalize competitive advantage, due to the fact that there are many intermediary moderating and mediating variables that can potentially obscure the effect of resources on higher-level performance metrics such as ROI, market share etc [34-36]. Instead, Ray et al. [36] suggests to choose process performance as the endogenous construct when testing the resource-based view empirically. Positive impact on process performance from supply-side activities has been observed earlier, for example through supply chain integration [37-39], early supplier involvement [40] and strategic supplier development [41]. Since this approach has proved to be successful in the past, global sourcing performance was selected as the endogenous construct in this particular study. Furthermore, process performance can also be dichotomized into two subcategories, namely effectiveness and efficiency. Here, effectiveness refers to the extent to which a pre-defined objective has been achieved, whereas efficiency refers to the extent of inputs needed to achieve those pre-defined objectives [42].

Hypothesis 1: Global sourcing efficiency is positively influenced by the level of external resources in possession by the firm.

Moreover, while dealing with effectiveness and efficiency, one must also consider the relationship between the two; which one follows the other? The logical answer is rather straightforward: In order to achieve effectiveness (i.e. accomplish a set of business objectives), resources are needed. Unless necessary resources are in place, and unless the economic returns exceed the cost of those resources invested, business objectives cannot be accomplished. In other words, for every business objective, the cost of achieving that objective must be considered (i.e. efficiency must be considered). Therefore, effectiveness must primarily follow efficiency and not vice versa. Based on this discussion, the third hypothesis can be defined as follows:

Hypothesis 2: Global sourcing effectiveness is positively influenced by the level of external resources in possession by the firm.

The next obvious question is how to acquire external resources. For this purpose, it is worthwhile investigating the types of resources that exist. Although numerous resource classification schemes exist, resources of the firm are usually categorized by their physical nature [43] or by what the company has or what it does [44-45]. Using this classification, one can identify organizational capabilities as a broad category that involves several dimensions such as skills [46] and invisible assets [47]. Anit and Schoemaker [48] defines capabilities as “the firm’s capacity to deploy Resources”, meaning that they represent what the firm is “doing” rather than what it is “having” [44]. Several scholars have claimed that organizational capabilities are not only based on the capabilities of the individual people, but also the inter-personal capabilities when employees work in teams [49-50], a notion derived from Nelson and Winter’s [51] concept of organizational routines. Capabilities have also been frequently been pointed out as the strategic factor that makes the firm dynamic in a sense that it lets the firm “renew competences” [52]. Moreover, several scholars claim capabilities to be the ultimate source of competitive advantage, as they make firms truly distinguishable and unique [45, 53].

This discussion fits quite well in a global sourcing context, as it is obvious that it takes certain organizational capabilities to acquire external resources in foreign countries. For example, as the degree of value added is decreasing, capabilities for effective supplier collaboration is becoming increasingly important in order to realize competitive advantages for the buying firm [54-55], and overcome the disadvantages of foreignness [56]. Furthermore, in order to successfully manage supplier relationships, the capability to share information and communicate is highly important [57], and is even more important when sourcing in emerging and transition economies where accurate information is scarce and uncertainty is high [58]. This statement is further supported by Harvey et al. [59] who state that both technical and social competencies are essential for effective supply management in global account relationships. Therefore, the fourth and final hypothesis is as follows:
Hypothesis 4: The level of external resources accessible to the firm is positively influenced by the level of global sourcing capabilities of the firm.

The hypotheses jointly form a conceptual framework as shown below.

**Figure 1. Conceptual framework**

Global Sourcing Capabilities

Global External Resources

Global Sourcing Efficiency

Global Sourcing Effectiveness

III. Data Collection

The survey methodology followed a standard research protocol where data was collected through computer-assisted telephone interviews (CATI). The initial questionnaire was pre-tested for time length, clarity and other problems. It was also translated into the corresponding language of the countries subject of study and then translated back to the original language to ensure that no meaning was lost during the translation. Before and during the pilot study, meetings were arranged with the interviewers on a regular basis in order to identify and solve problems that might arise during the interviews, but also as a means for eliminating potential problems associated with inexperience of the interviewers [60]. Only a few minor problem areas were identified and corresponding changes were implemented for the second wave of the survey. Random audio tapping were also carried out in order to assure face validity [61]. If a telephone number did not result in a completed questionnaire, another telephone number was randomly selected from a database consisting of 6,833 entries. Only native speakers of the corresponding countries were used in order to facilitate the execution of the interviews and reduce the risk for misunderstandings.

The Sample

A stratified sample for the study comprised Chief Procurement Officers and senior Purchasing Managers at business unit level of large-sized companies operating in France, Germany, Italy, Spain and the UK. These tend to be involved in decision-making regarding localization of sourcing activities. Furthermore, they are frequently positioned at board-level where strategic sourcing decisions normally are taken. Consequently, this category of respondents can be considered the most suitable for this study and hence key-informant bias is minimized [62]. The qualifying criterion for participation was an annual revenue exceeding 300 million euro. A total number of 200 interviews had been set as a target and all in all 1,273 phone calls had to be made in order to accomplish this. Out of the total number of calls, about 15 percent resulted in no answer, and another 14 percent resulted in an answering machine. Three percent of the numbers were invalid. The remaining total number of calls had to be made in order to accomplish this. Out of the original set of items, all calls had to be made in order to identify an answering machine. Furthermore, PGFI was 0.54, which indicates a high level of external resources accessible to the firm.

**Table 1. Industry representation**

<table>
<thead>
<tr>
<th>Industry</th>
<th>#Companies</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food and agriculture</td>
<td>32</td>
<td>16</td>
</tr>
<tr>
<td>Machinery</td>
<td>32</td>
<td>16</td>
</tr>
<tr>
<td>Energy/resources/material</td>
<td>24</td>
<td>12</td>
</tr>
<tr>
<td>Construction</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Automotive</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>Electronics</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>Pharma/Chemical</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>Telecom</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>Retail</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Transportation</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Financial services</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Others</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

Measures

All items were measured on a five-grade semantic scale ranging from one to five. The construct items were not rotated from interview to interview, but were randomly ordered. The questionnaire was pre-tested during a purchasing and supply management seminar with eight sourcing experts comprising a mix of researchers and industry practitioners. Items that were not immediately understood or found ambiguous were changed in their wording or dropped altogether unless it would detrimentally affect construct validity. Out of the original set of items, all constructs were operationalized through three items each.

IV. Analysis and Results

The analysis procedure was divided into two steps according to an approach as suggested by Anderson and Gerbing [66]. First, the measurement model was assessed, followed by testing of the structural model itself. The empirical data was analyzed through maximum likelihood (ML) structural equation modeling (SEM) using the statistics software package Amos v18.0.

Measurement Model

In order to assess convergent and discriminant validity for the various constructs used in this study, confirmatory factor analysis was applied. As a first step, assessment of convergent validity was performed. Obviously, there is evidence for convergent validity as all factor loadings were highly significant. The model fit indices used in this study were $\chi^2_{av} = 64.2$ ($p = 0.059$), $\chi^2/df = 1.34$, RMSEA = 0.046, GFI = 0.95, NFI = 0.91, CFI = 0.97 and standardized RMR = 0.053, indicating that the model was acceptable [67-68].

Furthermore, PGFI was 0.54, which indicates a high

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parsimonious fit [69]. Discriminant validity was evaluated through chi-square difference tests for each pair of constructs in the measurement model. For the measurement model, all constrained model specifications had significantly higher chi-square values than the oblique (i.e. unconstrained) model; hence, discriminant validity was deemed adequate.

Moreover, construct reliability was highly satisfactory, as the parameters for each corresponding latent variable exceeds 0.70 [70]. Furthermore, item analysis was conducted. Kumar et al. [71] suggest that item-to-total correlation should exceed 0.3; those lower than that do not share enough variance with the rest of the items in that scale. This criterion was also fulfilled in this study. Furthermore, a recommendation by Homburg [72] saying that average variance extracted should exceed 50 percent was apparently fulfilled with a good margin; in the case of this study, the amount of variance extracted ranged from 65.8 to 72.6 percent.

Path Analysis
After assessing the fit of the measurement model was assessed, the next step was to evaluate the previously defined hypotheses by examining the interrelations between the different constructs (Figure 2).

The model fit indices used in this study were $\chi^2$ = 58.8 ($p = 0.18$), $\chi^2/df = 1.18$, RMSEA = 0.049, GFI = 0.94, NFI = 0.90, CFI = 0.97 and standardized RMR = 0.062, indicating that the model was acceptable [67-68]. Furthermore, PGFI was 0.60, which indicates a high parsimonious fit [69]. The intuitive reason to the relatively high value is the low complexity of the model structure.

Evaluation of Hypotheses
Hypothesis 1 postulated the relationship between global external resources and global sourcing efficiency. In line with expectations, it turned out to be a significant predictor variable ($p = 0.002$) and the relationship was relatively high (0.31). Hence, hypothesis 1 was accepted. Hypothesis 2 explored the relationship between global external resources and global sourcing effectiveness. For this variable, the relationship was positive and strong (0.41), and also highly significant ($p < 0.001$). Thus, hypothesis 2 was accepted. Hypothesis 3 investigated the relationship between global sourcing efficiency and global sourcing effectiveness. As expected, it turned out to be a significant predictor variable ($p = 0.019$) and the relationship was moderately strong (0.25). Hence, hypothesis 3 was accepted. Finally, hypothesis 4 examined the relationship between global sourcing capability and access to global external resources. For this variable, the relationship was positive and very strong (0.82), and also highly significant ($p < 0.001$). Thus, hypothesis 4 was accepted. A an overview of the research model with path coefficients is shown in Figure 3.

Figure 3. Structural model with path coefficients

V. Conclusions
Global sourcing is a critical undertaking that needs careful strategy development and execution in order to yield total cost reduction while assuring quality and delivery [12]. Most prior research has focused on motivations for global sourcing [17], transaction-specific aspects [73] or international supplier evaluation [74]. This study provides a novel perspective on global sourcing by elucidating the interrelation between internal and external firm resources by extending extant theory on RBV. Furthermore, the empirical investigation on the role of firm-specific resources in a supply-side context provides insight in a topic that has yet only been examined theoretically [75-76].

Theoretical Contributions
From a theoretical perspective, the results clearly showed that capabilities has a very strong positive influence on acquisition of external resources and thus creation of competitive advantage, in line with the capability-based view [77]. Furthermore, the fact that firm capabilities played a very important role for acquiring and controlling external resources through global sourcing activities also support the notion of the strategic importance of purchasing and supply management that has been under debate for several years [75-76]. Also, the strong relationship between external resources and performance indicates the relevance and validity of RBV as a viable theoretical lens to explain the global sourcing phenomenon, but also creates a crucial linkage between RBV and the capability-based view which historically have been perceived as rather independent and disparate theories of the firm. Finally, the study results also highlighted the relationship and causal direction between effectiveness and efficiency which has been under scrutiny for a long time [78].

Managerial Implications
First, the results underline the necessity to have adequate resources in order to create competitive advantage from sourcing in emerging and transition economies. If global sourcing efforts fail to acquire and control scarce external resources, expectations will simply not materialize. This finding is supported by various anecdotal evidence where global sourcing objectives are frequently not accomplished [79].

Second, as activities at operational level are derived from strategy, this highlights the importance of purchasing and supply management, where managerial skills play a key role in locking up scarce resources in the external environment, allocating internal resources in order to maximize value creation, and ultimately generating superior market performance [75]. Earlier studies have shown that all too
often companies have vaguely defined sourcing strategies, which lead to disparate expectations, misallocation of resources and ultimately a vicious circle of declining performance [80].

Limitations of the Study and Suggestions for Future Research

The study has several limitations. First, the study is cross-sectional, which means that the results only provide a static picture of the current situation. Second, only large-sized firms were included in this study. Since large-sized firms generally have more resources available to deploy through subsidiaries in foreign countries, they can potentially overcome barriers associated with sourcing in emerging and transition economies. As a result, the results from this study may not be generalizable to small or medium-sized firms. Third, as the sample in this study represents a wide range of industries, one has to be cautious about drawing conclusions at industry-level as the number of firms in some industry categories (e.g. financial services) is very low and thus cannot provide any statistically significant results. Fourth, as the aim of this study is to validate a theoretical model for global sourcing, the number of predictors in this study is limited to twelve, as a means to preserve parsimony. Finally, as many firms have their own specific performance objectives, it is likely that the performance measures used in this study do not perfectly correspond to the measures of the responding firms.

VI. References


BENCHMARKING THE OPERATING EFFICIENCY OF U.S. AIRLINES USING DEA

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ABSTRACT

The financial meltdown that made headlines in September and October 2008 left many banks, insurance companies, automakers, and other institutions struggling for survival, and exacerbated the economic slowdown that was already underway in the US and abroad. The ensuing recession had a very negative impact on the airline industry in the United States with losses that ran into billions. In this paper, we illustrate the use of data envelopment analysis, an operations research technique, to analyze the operating efficiency of the U.S. airline industry by benchmarking a set of ratios that assess the operating efficiency of a firm against its peers. Data envelopment analysis clearly brings out the airline(s) that is (are) operating more efficiently in comparison to other airlines in the industry, and points out the areas in which poorly performing airlines need to improve.

Keywords: Benchmarking, Data Envelopment Analysis, Airline, Operational Efficiency

INTRODUCTION

The financial meltdown that made headlines in September and October 2008 left many banks, insurance companies, automakers, and other institutions struggling for survival, and exacerbated the economic slowdown that was already underway in the US and abroad. The resulting stock market and housing market struggles left many consumers feeling poorer and less inclined (or able) to open their wallets. As a result, both consumer and business spending dampened considerably. In addition, the tightness of financial markets has limited airlines’ access to capital markets. According to Standard & Poor’s calculations, the 10 largest US airlines lost about $4.7 billion in 2009, as a sharp drop in demand, particularly among business travelers, more than offset the sharp drop in oil prices that led to much lower jet fuel costs. The drop-off in business and leisure travel demand led to significant yield degradation and a much less profitable passenger mix, as many more leisure travelers flying on discounted tickets took the place of business travelers. The industry was profitable in 2006 and 2007 following five years of multibillion-dollar losses, but was unprofitable in 2008 on rising fuel costs throughout the year. Although the airline industry’s operating environment has been brutal since 2001, carriers that operated with low costs and low fares were generally able to cope better than their higher-cost counterparts were.

The airline industry is both labor- and capital-intensive. Additionally, fuel costs have absorbed a growing portion of revenues in recent periods. As of December 31, 2009, the US commercial aviation industry consisted of 18 major air carriers (those flying aircraft with over 90 seats) and 66 regional carriers (using smaller piston, turboprop, and jet aircraft), according to the Federal Aviation Administration (FAA). The FAA also estimates that the number of aircraft in the US commercial fleet, including regional carriers, totaled 7,123 at the end of 2009, a decrease of 323 aircraft from the end of 2008. The 2009 number included 3,666 mainline air carrier passenger aircraft (jets with more than 90 seats), 845 all-cargo aircraft, and 2,612 regional aircraft (smaller jets, turboprops, and pistons).

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The recent history of the airline industry has been one of shrinkage, fueled by consolidation and bankruptcies. Mergers, capacity cuts, bankruptcy filings, large-scale losses, and high debt levels are the legacy of the first decade of the new millennium, and represent challenges that are likely to persist for some time. In 2010, United Airlines merged with Continental Airlines. Northwest Airlines had merged with Delta Airlines. Southwest Airlines has recently announced plans to acquire Air Tran. Airlines are currently fighting the perception that they are a major source of greenhouse gases by listing all the ways they have reduced jet fuel usage over the past 10 years: modernizing their fleets to more fuel efficient planes, efforts to control fuel use, and modifications to existing planes to increase fuel efficiency, to name a few. Though the airlines may have undertaken these initiatives to cut costs in the wake of high oil prices, they are using their accomplishments as a way to ease environmental concerns. Global recession is hurting this industry more than anything else due to decline in business and leisure travel and as a result, chapter 11 bankruptcies loom for smaller regional air carriers. Since the terrorist strikes in 2001, a number of federally mandated security measures have been put into effect—both to reassure the flying public and to prevent future occurrences. Airlines are now required to either screen all bags for explosives or make sure each bag is matched to a passenger seated on that flight—time-consuming and expensive initiatives. High crude oil prices continue to remain a concern for the airline industry and a source of concern and losses.

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PREVIOUS STUDIES

Numerous studies have analyzed the operating efficiency of firms using data envelopment analysis models. Hung, Lu, and Wang (2010) explore the operating efficiency, the scale efficiency targets, and the variability of DEA efficiency estimates of Asian container ports. Joo, Min, Kwon, and Kwon (2010) use data envelopment analysis to assess the operating efficiency of specialty coffee retailers from the perspective of socially responsible global sourcing. They evaluate the impact of socially responsible sourcing on the operating efficiencies of specialty coffee retailers before and after implementing fair-trade practices. Their study also compares the operating efficiencies of fair-trade coffee retailers to those of non-fair-trade coffee retailers. Hung and Lu (2008) study applies the Data Envelopment Analysis (DEA) approach with the classical radial measure, non-radial efficiency measure and efficiency achievement measure, respectively, combining multiple outputs and inputs to measure the magnitude of performance differences between the IC firms. Shimshak and Lenard (2007) present a Two-Model approach for including quality measures in DEA studies. This approach allows decision-makers to evaluate two models simultaneously, one measuring operational efficiency and the second measuring quality efficiency. This new method selects only DMUs that are efficient in both operational and quality measures to be members of the benchmark set. Their study demonstrates the Two-Model DEA approach using data from the nursing home industry. Lu, Yang, Hsiao, and Lin (2007) study uses the CCR model of Data Envelopment Analysis (DEA) and the slack variable analysis to evaluate the operating efficiency of the domestic banks in Taiwan from 1998 to 2004. Using data from the Annual Survey of Hospitals compiled by the Department of Health in Taiwan for years 1994 through 1997, Chang, Chang, Das, and Li (2004) use Data Envelopment Analysis (DEA) to evaluate the impact of a National Health Insurance (NHI) Program on the operating efficiency of district hospitals in Taiwan. Anderson, Fok, Springer, and Webb (2002) measure the technical efficiency and economies of scale for real estate investment trusts (REIT) by employing data envelopment analysis (DEA). Using data from the National Association of Real Estate Investment Trusts (NAREITs) for the years 1992-1996, they report that REITs are technically inefficient, and the inefficiencies are a result of both poor input utilization and failure to operate at constant returns to scale. Golany, Roll, and Ryback (1994) study applies data envelopment analysis (DEA) for measuring and evaluating the operating efficiency of power plants in the Israeli Electric Corporation is discussed.

In this paper, we extend previous studies by illustrating the use of DEA models to benchmark the performance of airline industry in terms of financial performance. No previous study has airlines in terms of financial performance.

MODEL

The Data Envelopment Analysis Model

The Data Envelopment Analysis (DEA) (Charnes et al., 1978) is a widely used optimization-based technique that measures the relative performance of decision making units that are characterized by a multiple objectives and/or multiple inputs structure. Data envelopment analysis is a technique used to assess the comparative efficiency of homogenous operating units such as schools, hospitals, utility companies, sales outlets, prisons, and military operations. More recently, it has been applied to banks (Haslem, Scheraga, & Bedingfield, 1999) and mutual funds (Haslem & Scheraga, 2003; Galagedera & Silvapulle, 2002; McMullen & Strong, 1998; Murthi, Choi, & Desai, 1997). It is a powerful technique for measuring performance because of its objectivity and ability to handle multiple inputs and outputs that can be measured in different units. The DEA approach does not require specification of any functional relationship between inputs and outputs, or a priori specification of weights of inputs and outputs. DEA provides gross efficiency scores based on the effect of controllable and uncontrollable factors.

The DEA methodology measures the performance efficiency of organization units called Decision-Making Units (DMUs). This technique aims to measure how efficiently a DMU uses the resources available to generate a set of outputs. The performance of DMUs is assessed in DEA using the concept of efficiency or productivity defined as a ratio of total outputs to total inputs. Efficiencies estimated using DEA are relative, that is, relative to the best performing DMU or DMUs (if multiple DMUs are the most efficient). The most efficient DMU is assigned an efficiency score of unity or 100 percent, and the performance of other DMUs vary between 0 and 100 percent relative to the best performance.

Consider a set of n observations on the DMUs. Let us define the following:

\[ j = 1, 2, \ldots, n \text{ DMU.} \]
\[ i = 1, 2, \ldots, m \text{ inputs} \]
\[ r = 1, 2, \ldots, s \text{ outputs} \]

Each observation, DMU, \( j = 1, 2, \ldots, n \), uses:

\[ x_{ij} \text{ amount of input } i \text{ for unit } j, i = 1, 2, \ldots, m \]
\[ y_{jr} \text{ amount of output } r \text{ for unit } j, r = 1, 2, \ldots, s \]

The DEA methodology gives a measure of efficiency that is defined as the ratio of weighted outputs to weighted inputs. The most important issue in this method is the assessment of the weights. Charnes et al. define the efficiency measure by assigning to each unit the most favorable weights. In general, the weights will not be the same for different units. Further, if a unit happens to be inefficient, relative to the others, when most favorable weights are chosen, then it is inefficient, independent of the choice of weights. Given these weights, the efficiency of a DMU in converting the inputs to outputs can be defined as the ratio of weighted sum of output to weighted sum of inputs.
The weights for a DMU are determined using mathematical programming as those that will maximize the efficiency of a DMU subject to the condition that the efficiency of other DMUs (calculated using the same set of weights) is restricted to values between 0 and 1. The weights are chosen that only most efficient units will reach the upper bound of the efficiency measure, chosen as 1. Let us take one of the DMUs, say the oth DMU as the reference DMU under evaluation whose efficiency (Eo) is to be maximized. Therefore, to compute the DEA efficiency measure for the oth DMU, we have to solve the following fractional linear programming model:

$$\text{Efficiency} = \sum_{i=1}^{m} y_{ij} x_{ij}$$

(1)

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The weights for a DMU are determined using mathematical programming as those that will maximize the efficiency of a DMU subject to the condition that the efficiency of other DMUs (calculated using the same set of weights) is restricted to values between 0 and 1. The weights are chosen that only most efficient units will reach the upper bound of the efficiency measure, chosen as 1. Let us take one of the DMUs, say the oth DMU as the reference DMU under evaluation whose efficiency (Eo) is to be maximized. Therefore, to compute the DEA efficiency measure for the oth DMU, we have to solve the following fractional linear programming model:

$$\text{Efficiency} = \sum_{i=1}^{m} y_{ij} x_{ij}$$

(1)

The weights for a DMU are determined using mathematical programming as those that will maximize the efficiency of a DMU subject to the condition that the efficiency of other DMUs (calculated using the same set of weights) is restricted to values between 0 and 1. The weights are chosen that only most efficient units will reach the upper bound of the efficiency measure, chosen as 1. Let us take one of the DMUs, say the oth DMU as the reference DMU under evaluation whose efficiency (Eo) is to be maximized. Therefore, to compute the DEA efficiency measure for the oth DMU, we have to solve the following fractional linear programming model:

$$\text{Efficiency} = \sum_{i=1}^{m} y_{ij} x_{ij}$$

(1)
summarized in the following DEA model:

$$\min \ 0 - \varnothing \left( \sum_{i=1}^{m} s_{i}^{0} + \sum_{r=1}^{s} s_{r}^{0} \right)$$
subject to

$$\sum_{j=1}^{n} \lambda_{r} x_{ij} + s_{i}^{0} = \theta x_{rj}, \ i = 1, \ldots, m$$

$$\sum_{j=1}^{n} \lambda_{r} y_{rj} - s_{r}^{0} = y_{rj}, \ r = 1, \ldots, s$$

$$(12)$$

$$\lambda_{r} \geq 0,$$

$$0 \ unrestricted.$$

**DATA AND METHODOLOGY**

We used the data available from Standard & Poor’s NetAdvantage for this study. We used three operational efficiency variables (year 2009) to evaluate eight United States airlines. Eight companies that we include in our study are: Airtran, Alaska, AMR, Delta, JetBlue, Southwest, USAir, and United Airlines. These are the eight largest airlines operating in United States. We benchmark the operational performance of these companies on the basis of the following functional variables: Operating Cost as Percentage of Revenue – Operating Cost as Percentage of Revenue is the sum of fuel expense as percentage of revenue and labor cost as percentage of revenue, Fixed Assets Turnover Ratio - Fixed Assets Turnover Ratio is the ratio of sales and net property and plant equipment, Passenger Load Factor - Passenger Load Factor is an indicator of the capacity utilization of the airline. Table 2 illustrates the pooled data of the eight airlines used for analysis.

**Data Envelopment Model Specifications for the Airline Industry**

Besides the mathematical and computational requirements of the DEA model, there are many other factors that affect the specifications of the DEA model. These factors relate to the choice of the DMUs for a given DEA application, selection of inputs and outputs, choice of a particular DEA model (e.g. CRS, VRS, etc.) for a given application, and choice of an appropriate sensitivity analysis procedure (Ramanathan, 2003). Due to DEA’s non parametric nature, there is no clear specification search strategy. However, the results of the analysis depend on the inputs/outputs included in the DEA model. There are two main factors that influence the selection of DMUs – homogeneity and the number of DMUs. To successfully apply the DEA methodology, we should consider homogenous units that perform similar tasks, and accomplish similar objectives. In our study, the companies are homogenous as they are identified by Standard and Poor’s NetAdvantage to be competitors. Furthermore, the number of DMUs is also an important consideration. In addition, the number of DMUs should be reasonable so as to capture high performance units, and sharply identify the relation between inputs and outputs. The selection of input and output variables is the most important aspect of performance analysis using DEA. In general, the inputs should reflect the level of resources used or a factor that should be minimized. The outputs reflect the level of the economic variable factor, and the degree to which an economic variable contributes to the overall strength (efficiency) of a company. There are some simple rules of thumb that guide the selection of inputs and outputs, and the number of participating DMUs.

To study the performance of the airline industry, we consider three factors to develop the DEA model: operating cost as percentage of revenue, fixed assets turnover ratio, and passenger load factor.

Out of these three factors, we specify operating cost as percentage of revenue and fixed assets turnover ratio as input, because for a given airline the lower these variables are the better the performance of the airline is. Similarly, passenger load factor implies a better-performing company. Thus, we consider this variables as output variables. Finally, the choice of the DEA model is also an important consideration. We should select the appropriate DEA model with options such as input maximizing or output minimizing, multiplier or envelopment, and constant or variable returns to scale. DEA applications that involve inflexible inputs or not fully under control inputs should use output-based formulations. On the contrary, an application with outputs that are an outcome of managerial goals, input-based DEA formulations are more appropriate. In addition, for an application that emphasizes inputs and outputs, we should use multiplier version. Similarly, for an application that considers relations among DMUs, envelopment models are more suitable. Furthermore, the characteristics of the application dictate the use of constant or variable returns to scale. If the performance of DMUs depends heavily on the scale of operation, constant returns to scale (CRS) is more applicable, otherwise variable returns to scale is a more appropriate assumption.

In our study, the comparative evaluation among the airlines is an important consideration. Therefore, we select the envelopment models for our analysis. In addition, the outputs are an outcome of managerial goals. Therefore, input-based formulation is recommended for our study. The objective of the analysis is to suggest a benchmark for the airline firms. Furthermore, to investigate the affect of scale of operations, if any, among the 8 companies, we consider both variable

---

1 The following are the guidelines for DMU model selection:

a. The number of DMUs is expected to be larger than the product of number of inputs and outputs (Darrat et. Al., 2002; Avkiran, 2001) to discriminate effectively between efficient and inefficient DMUs. The sample size should be at least 2 or 3 times larger than the sum of the number of inputs and outputs (Ramanathan, 2003).

b. The criteria for selection of inputs and outputs are also quite subjective. A DEA study should start with an exhaustive, mutual list of inputs and outputs that are considered relevant for the study. Screening inputs and outputs can be quite quantitative (e.g. statistical) or qualitative that are simply judgmental, use expert advice, or use methods such as analytical hierarchy process (Saaty, 1980). Typically inputs are the resources utilized by the DMUs or condition affecting the performance of DMUs. On the other hand, outputs are the benefits generated as a result of the operation of the DMUs, and records higher performance in terms of efficiency. Typically, we should restrict the total number of inputs and outputs to a reasonable level. As the number of inputs and outputs to a reasonable level. As the number of inputs and outputs increases, more number of DMUs get an efficiency rate of 1, as they become too specialized to be evaluated with respect to other units (Ramanathan, 2003).
returns to scale and constant returns to scale DEA models. Also, the structure of the DEA model (in envelopment form) uses an equation and separate calculation for every input and output. Therefore, all the input and output variables can be used simultaneously and measured in their own units. In this study, we use the Input-Oriented Variables Return to Scale (VRS) to evaluate the efficiency of eight companies for the year 2009.

Figure 1 illustrates a decision support system using data envelopment analysis. The decision support system uses the DEA methodology to determine how good a firm is. The DEA-based decision support system uses the company attributes – operating cost as percentage of revenue as input variable. The system uses passenger load factor and fixed assets turnover ratio as output variables to calculate efficiency score for a firm. This score is a relative value computed by comparing the given firm to a pool of well-performing companies that serve as a benchmark for the company under evaluation. Each firm is evaluated against the existing firms with an identical set of inputs or outputs that is constructed as a combination of performing and non-performing companies. By using the existing good companies as a “role model,” DEA not only helps differentiate well performing (efficient companies from poorly performing (inefficient) firms, but also brings out the reasons why a company may be underperforming. This helps investors and creditors justify their decisions to invest or not to invest their funds in a particular company. This will also help management identify areas of weakness for a firm so that management plans can focus on plugging the weaknesses or taking steps to counter the weaknesses.

EMPIRICAL ANALYSIS

Each of the airline company is a homogenous unit, and we can apply the DEA methodology to assess the comparative performance of these companies. This study evaluates the status of the airline industry by benchmarking the relative performance of eight companies against each other in the industry. Using the DEA methodology, we can calculate an efficiency score for the 8 companies on a scale of 1 to 100. We analyze and compute the efficiency of these companies using the financial statements for the year 2009. Table 3 illustrates the efficiency scores for eight companies. Further, we also study the peers (model companies) for inefficient companies. Table 3 shows the relative performance of the airline companies benchmarked against each other. Table 3 also shows that one out of eight companies was ranked as efficient till December 2009, and seven companies were inefficient companies. US Air was 100% efficient. On the other hand, Airtran, Alaska, AMR, Delta, JetBlue, Southwest, and United Airlines are inefficient. Figure 2 shows the efficiency frontier graph of the pooled company data. The 100% efficient companies (blue dots) are on the efficiency frontier, where as the inefficient companies (red dots) are inside the efficiency frontier. The DEA Analyzer calculates the level of inefficiency by measuring the distance between the efficiency frontier and the inefficient companies. Therefore, an operational manager can use this efficiency frontier to assess the relative efficiency of the firm in the industry. The DEA model compares the operating cost as percentage of revenue, fixed assets turnover ratio, and passenger load factor.

We present the score in percentage value varying between 0% and 100%. We find that the input efficiency of US Air is 100%. On the other hand, the input efficiency of the remaining companies are: Airtran (77%), Alaska (80%), AMR (62%), Delta (76%), JetBlue (7%), Southwest (64%), and United Airlines (88%). This means that the observed level of fixed assets turnover ratio, and passenger load factor for Airtran can be achieved with 77% of the current levels of operating cost as percentage of revenue. The same rationale applies to Alaska (80%), AMR (62%), Delta (76%), JetBlue (7%), Southwest (64%), and United Airlines (88%). Table 4 illustrates the efficiency scores and the corresponding ranking of the pooled companies in the year 2009. The average score is 80%, with four companies having efficiency levels above average while the remaining four are below the average level. The 100% efficient company is, is the best practice company within the pooled database of the Decision Support System. The best practices companies US Air is 100% efficient. As all other airlines are inefficient; the next step is to identify the efficient peer group or companies whose operating practices can serve as a benchmark to improve the performance of these companies. Table 5 illustrates the peer group for the inefficient companies. As shown in the Table 5, US Air serves as a peer for Alaska, AMR, Delta, JetBlue, Southwest, and United Airlines as US Air is the only 100% efficient company. Thus, Alaska, AMR, Delta, JetBlue, Southwest, and United Airlines should emulate US Air.

After calculating the efficiency of a company using DEA, and identifying the efficient peers, the next step in DEA analysis is feasible expansion of the output or contraction of the input levels of the company within the possible set of input-output levels. The DEA efficiency measure tells us whether or not a given company can improve its performance relative to the set of companies to which it is being compared. Therefore, after minimizing the input efficiency, the next stage involves calculating the optimal set of slack values with an assurance that input efficiency will not decrease at the expense of slack values of the input and output factors. Once efficiency has been minimized, the model does seek the maximum sum of the input and output slacks. If any of these values is positive at the optimal solution to the DEA model that implies that the corresponding output of the company (DMU) can improve further after its output levels have been raised by the efficiency factor, without the need for additional input. If the efficiency is 100% and the slack variables are zero, then the output levels of a company cannot be expanded jointly or individually without raising its input level. Further, its input level cannot be lowered given its output levels. Thus, the companies are pareto-efficient with technical output efficiency of 1. If the company is 100% efficient but one slack value is positive at the optimal solution then the DEA model has identified a point on the efficiency frontier that offers the same level on one of the outputs as company A in question, but it offers in excess of the company A on the output corresponding to the positive slack. Thus, company A is not Pareto-efficient, but with radial efficiency of 1 as its output cannot be expanded jointly. Finally, if the company A is not
SUMMARY AND CONCLUSIONS

Traditional operational efficiency analysis techniques uses fuel cost as a percentage of revenue, labor cost as a percentage of revenue, Sales/Net Property, Plant & Equipment, and percentage load factor to compare a firm’s performance against its peers in the industry as well as against the company’s historical performance. On the basis of this comparison, analyst will recommend whether the company is doing well or underperforming relative to its peers or relative to its own past performance. DEA employs relative efficiency, a concept enabling comparison of companies with a pool of known efficient companies. The DEA model compares a firm with the pool of efficient companies by creating an efficiency frontier of good firms—a tolerance boundary created by establishing the efficiency of firms in terms of several sets of financial ratios. Companies lying beyond this boundary can improve one of the input values without worsening the others. We found that US Air is 100% efficient. On the other hand Airtran, Alaska, AMR, Delta, JetBlue, Southwest, and United Airlines are inefficient. We also illustrate the areas in which inefficient companies are lacking behind efficient firms.

We also provide an insight into the benefits of DEA methodology in analyzing operational efficiency of the airlines industry. The decision support system stores the company’s historical data, competitive firm’s data, and other industry specific data, and uses the DEA methodology to analyze a firm’s performance. Moreover, DEA modeling does not require prescription of the functional forms between inputs and outputs. DEA uses techniques such as mathematical programming that can handle a large number of variables and constraints. As DEA does not impose a limit on the number of input and output variables to be used in calculating the desired evaluation measures, it’s easier for loan officers to deal with complex problems and other considerations they are likely to confront.

Table 1: Generalized DEA Models

<table>
<thead>
<tr>
<th>Frontier Type</th>
<th>Input-Oriented</th>
<th>Output-Oriented</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRS</td>
<td>( \max \sum \lambda_i x_{ij} + \sum \lambda_j y_i )</td>
<td>( \min \sum \lambda_i x_{ij} )</td>
</tr>
<tr>
<td>VRS</td>
<td>( \lambda_i \leq 1 )</td>
<td>( \lambda_i \leq 1 )</td>
</tr>
<tr>
<td>NIRS</td>
<td>Add ( \sum \lambda_i \geq 1 )</td>
<td>Add ( \sum \lambda_i \geq 1 )</td>
</tr>
<tr>
<td>1-1</td>
<td>j=1</td>
<td>j=1</td>
</tr>
<tr>
<td>NDRS</td>
<td>Add ( \sum \lambda_i \geq 1 )</td>
<td>Add ( \sum \lambda_i \geq 1 )</td>
</tr>
<tr>
<td>j=1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Pooled Data Set of Airline Companies for Year 2008

<table>
<thead>
<tr>
<th>Airline</th>
<th>Operating Cost</th>
<th>Sales/Net Property, Plant &amp; Equip</th>
<th>passenger load factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airtran</td>
<td>4.984967</td>
<td>1.774</td>
<td>0.798</td>
</tr>
<tr>
<td>Alaska</td>
<td>4.84205</td>
<td>1.073</td>
<td>0.786</td>
</tr>
<tr>
<td>AMR</td>
<td>6.205754</td>
<td>1.287</td>
<td>0.8</td>
</tr>
<tr>
<td>Delta</td>
<td>5.067883</td>
<td>1.373</td>
<td>0.82</td>
</tr>
<tr>
<td>Jet Blue</td>
<td>5.237371</td>
<td>0.708</td>
<td>0.797</td>
</tr>
<tr>
<td>Southwest</td>
<td>6.050892</td>
<td>0.973</td>
<td>0.76</td>
</tr>
<tr>
<td>USAir</td>
<td>3.851597</td>
<td>2.83</td>
<td>0.819</td>
</tr>
<tr>
<td>UAL</td>
<td>4.394245</td>
<td>1.66</td>
<td>0.819</td>
</tr>
</tbody>
</table>
Table 3: DEA Efficiency Scores for the Airline Companies.

A company with 100% score is considered the most efficient and a company with less than 100% score is considered inefficient. Efficiency scores is based on fuel cost as a percentage of revenue, labor cost as a percentage of revenue, sales/net plant and machinery, and passenger load factor.

<table>
<thead>
<tr>
<th>Company</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airtran</td>
<td>77%</td>
</tr>
<tr>
<td>Alaska</td>
<td>80%</td>
</tr>
<tr>
<td>AMR</td>
<td>62%</td>
</tr>
<tr>
<td>Delta</td>
<td>76%</td>
</tr>
<tr>
<td>Jet Blue</td>
<td>97%</td>
</tr>
<tr>
<td>Southwest</td>
<td>64%</td>
</tr>
<tr>
<td>USAir</td>
<td>100%</td>
</tr>
<tr>
<td>UAL</td>
<td>88%</td>
</tr>
</tbody>
</table>

Figure 1: Decision Support System using Data Envelopment Analysis

Figure 2: Efficiency Frontier for the Benchmarked Companies.

Table 4: Efficiency Score and Ranking of the 8 Airlines for 2009.

<table>
<thead>
<tr>
<th>Airline</th>
<th>Efficiency</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>USAir</td>
<td>100%</td>
<td>1</td>
</tr>
<tr>
<td>Jet Blue</td>
<td>97%</td>
<td>2</td>
</tr>
<tr>
<td>UAL</td>
<td>88%</td>
<td>3</td>
</tr>
<tr>
<td>Alaska</td>
<td>80%</td>
<td>4</td>
</tr>
<tr>
<td>Airtran</td>
<td>77%</td>
<td>5</td>
</tr>
<tr>
<td>Delta</td>
<td>76%</td>
<td>6</td>
</tr>
<tr>
<td>Southwest</td>
<td>64%</td>
<td></td>
</tr>
<tr>
<td>AMR</td>
<td>62%</td>
<td>8</td>
</tr>
<tr>
<td>Average</td>
<td>80%</td>
<td></td>
</tr>
</tbody>
</table>

Table 5: Peer Companies and their weights in percentage

This table shows those companies that can serve as a benchmark for companies with DEA efficiency score of less than 100.

<table>
<thead>
<tr>
<th>Airline</th>
<th>efficiency</th>
<th>USAir</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airtran</td>
<td>77%</td>
<td>1.00</td>
</tr>
<tr>
<td>Alaska</td>
<td>80%</td>
<td>1.00</td>
</tr>
<tr>
<td>AMR</td>
<td>62%</td>
<td>1.00</td>
</tr>
<tr>
<td>Delta</td>
<td>76%</td>
<td>1.00</td>
</tr>
<tr>
<td>Jet Blue</td>
<td>97%</td>
<td>1.00</td>
</tr>
<tr>
<td>Southwest</td>
<td>64%</td>
<td></td>
</tr>
<tr>
<td>USAir</td>
<td>100%</td>
<td>1.00</td>
</tr>
<tr>
<td>UAL</td>
<td>88%</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Table 6: Slack Variables for Inefficient Companies (efficiency < 100%) (2008)

Table shows the adjustment needed in each of the three operational variables for an inefficient company to become efficient.

<table>
<thead>
<tr>
<th>Airline</th>
<th>efficiency</th>
<th>Operating Cost</th>
<th>Sales/Net Property, Plant &amp; Equip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airtran</td>
<td>77%</td>
<td>0.00</td>
<td>1.06</td>
</tr>
<tr>
<td>Alaska</td>
<td>80%</td>
<td>0.00</td>
<td>1.06</td>
</tr>
<tr>
<td>AMR</td>
<td>62%</td>
<td>0.00</td>
<td>1.76</td>
</tr>
<tr>
<td>Delta</td>
<td>76%</td>
<td>0.00</td>
<td>1.54</td>
</tr>
<tr>
<td>Jet Blue</td>
<td>97%</td>
<td>1.22</td>
<td>0.00</td>
</tr>
<tr>
<td>Southwest</td>
<td>64%</td>
<td>1.22</td>
<td>0.00</td>
</tr>
<tr>
<td>USAir</td>
<td>100%</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>UAL</td>
<td>88%</td>
<td>0.00</td>
<td>1.17</td>
</tr>
</tbody>
</table>

REFERENCES

Available upon request from the author.
FOREIGN CUSTOMERS’ WORD OF MOUTH ON SERVICE INDUSTRY IN TAIWAN

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ABSTRACT

This study aims to investigate the WOM from the foreigners’ perspectives on Taiwan’s service industry. An exploratory research was conducted using semi-structure interview and critical incidents technique to identify the incidents and to develop dimensions of foreign consumers’ WOM. Seventy participants were recruited to recall their WOM in five main services including transportation, convenient store, restaurant, healthcare, and banking. The results found most of the study participants were more likely to mention positive arguments during the WOM. The 285 critical incidents are included in four main groups such as physical environment, employee attitude/behavior, value, and functionality. The findings provide the fundamental first step in developing a comprehensive understanding of foreign consumers’ WOM

Keywords: Word of mouth, foreign customers, services, Taiwan.

INTRODUCTION

A widely accepted notion in organizations is that well-trained employees are crucial in ensuring long term relationship and consumer satisfaction. For instance, employees’ quick and attentive responses to a service failure can both be an indicator of excellent service quality [1] and also help to retain consumers from switching to another brand [2]. But, will the same instances about the firm’s employee be the central of discussion when the same consumer is having a conversation with others?

In consumer behavior, most customers were found engaging in word of mouth (WOM) to satisfy their personal information [3] and psychological needs (e.g., due to cognitive dissonance). And word-of-mouth (WOM) communication plays an important role in shaping consumers’ attitudes and behaviors [4]. Katz and Lazarsfeld [5] found that WOM was seven times more effective than newspaper and magazine advertising, four times more effective than personal selling, and twice as effective as radio advertising in influencing consumers to switch brands. After that, Day [6] computed that WOM was nine times as effective as advertising at converting unfavorable or neutral predispositions into positive attitudes. Recently, Mangold et al. [7] defined that a consumer is five times more likely to engage in WOM if the encounter is pleasant and as high as nine times if the encounter is considered to be unpleasant experience. The high tendency of consumers to engage in negative WOM is further stressed by Warden et al. [8], which emphasized retaining consumers’ goodwill is crucial in order to avoid reprisal from customers’ bad word of mouth.

With the tremendous improvement in means of transportation and technology, travelling or immigration is no longer posed as difficulty to the modern day travelers. And there has been scant body of research focusing on foreign customers’ WOM in relation to the local service setting. For example, studies results that while all the services are inseparability, the intercultural differences can further complicates by introducing consumers to a foreign culture [8]. Stauss and Mang [9] defined cultural differences as instrumental for escalating the opportunity of the service gaps. However, a few studies investigate the positive and negative WOM experience of foreigners’ perspective in local service industry. And it seems clear that additional research is needed.

The purpose of this study is to investigate the WOM from the foreigners’ perspectives in relation to the non-domestic service marketplace. Since there have been few studies on the topic, an exploratory research was conducted among the non-local service customers (e.g., foreigners) to investigate two questions: What are critical events, combinations of events, or series of events that were mentioned by these foreign consumers during WOM? Can generalizations be drawn out of the foreign consumer perception on WOM? The following objectives were developed:

1. To identify the incidents that had been communicated by foreign consumers during their WOM relating to the service industry in Taiwan.

2. To develop dimensions of WOM from foreign customers’ perspective on service industry in Taiwan.

Given to the context of this study, an empirical study applying the critical incident technique (CIT) was conducted. To further facilitate the present study, we focus service industry and international students as its foreign consumers in Taiwan.

LITERATURE REVIEW

WORD OF MOUTH AND SERVICE INDUSTRY

WOM is an informal communication that was directed at other consumers about ownership, or characteristics of particular goods and services or their sellers [10]. As for the marketers, WOM functions as an informal advertisement in consumer communication [11], and helps to supplement the mass-media. The credibility of WOM as a medium of persuasion can be largely attributes to the fact that the communicator is not seen as having a vested interest in selling a recommended product or service, and he/she is likely to portray the information in a meaningful way [12]. Unlike the tangible product which is covered by manufacturer guarantee and warranty in case of product failure, the intangible nature of service offers no such assurance. For that, WOM provides customers with some comfort by offering assurance, and also
INfluences customers’ purchase decision.

WOM is particularly important in the marketing of services. Consumers have been found to rely on WOM to reduce the level of perceived risk and uncertainty that are often associated with service purchase decisions [13]. According to Mangold et al. [7], the most important factors triggering WOM were (1) the needs of information from the receivers, (2) coincidental WOM (e.g., a general discussion on plans over the weekend that eventually led to comments about the quality of a particular restaurant), (3) communicators’ satisfaction/dissatisfaction (4) from observance of the purchase or its outcome (e.g., a positive communication about a hair salon began with the compliment about the communicator’s new hair style), (5) when there are two or more people trying to select a service.

Previous studies have researched several determinants of the positive and negative WOM activities. With respect to positive WOM, studies show that satisfied customers are prone to engage in positive WOM [14] [15]. Moreover, an intention to engage in positive WOM is positively correlated with customer perceptions of value and quality [16]. Positive WOM is also triggered by feelings of equity (i.e., “fair deal”) [14], product/service performances [17] and by the perceived social supports displayed by the service providers (i.e. verbal and non-verbal communication toward the customer) [18]. In contrast, the antecedents of negative WOM which is considered to be one of the forms for customer complaining behavior [19] have also been investigated. Soderlund [15], for example, found a fairly symmetrical relationship between satisfaction and WOM; just as favorable satisfaction triggers off positive WOM, dissatisfaction leads to negative WOM. High price, difficulty of repair, consumer’s external attributions of blame (in case of product failure) and consumer’s negative perceptions of the retailer responsiveness to complaints were also shown to be positively related to negative WOM [20].

INTERNATIONAL STUDENTS AS FOREIGN CUSTOMERS IN TAIWAN

International students in Taiwan are now a common phenomenon. The proportion of international students in Taiwan has increased significantly in the past few years. This is due to the high incentives of many universities in Taiwan to open their doors and lower thresholds for incoming international students [21]. Under the Ministry of Education’s policy of “internationalizing universities,” from 2005 various private and national universities as well as technical colleges began offering “university scholarships” to attract international students, via subsidies from the government supplemented by additional funds provided by the institutions themselves. Thus, the scholarships provided by the Taiwan government and universities are a major attraction for international students. Besides, tuition fees and the costs of living are lower in Taiwan than in most developed countries [22].

According to the Ministry of Education, in 2007, the total number of students (including degree-level, exchange, and language study students) reached 17,742. The number of foreigners enrolled as undergraduate or graduate students at Taiwan’s universities has grown 20–30% per annum since then until now. In 2008, a total of 19,496 international students, hailing from more than 110 nations, were scattered at more than 100 universities throughout Taiwan. There are over 20 university campuses in Taiwan with over 100 international students. National Chengchi University, National Taiwan University and National Cheng Kung University have over 500 international students each [23]. A huge number of international students come from variety of countries, different economic backgrounds and stay in Taiwan in a period for studies, which help them have time to use and feel local services.

RESEARCH METHOD AND PROCEDURE

Consistent with the exploratory nature and the objectives of the present study, the CIT method (critical incident technique) was considered to be more appropriate. We began by collecting the actual incidents that were communicated in the WOM by foreigners about services in Taiwan. In contrast to the hypothetic-deductive approach which a priori theory is superimposed on the data, the exploratory development allowed patterns of experience to emerge from the data.

DATA COLLECTION

Critical incident technique (CIT)

We use CIT to explore all aspects of WOM from the consumer’s WOM. Flanagan [24], the developer of CIT, defined it as “a set of procedures for collecting direct observations of human behavior in such a way as to facilitate their potential usefulness in solving practical problems and developing broad psychological principles.” By an incident, it refers to any specifiable human activity that is sufficiently complete in itself to permit inferences and directions to be made about the person performing the act. To be ‘critical’, the incident must occur in a situation where the purpose or intent of the act seems fairly clear to the observer and where its consequences are sufficiently definite to leave little doubt concerning its effects. An incident is deemed critical when it “contributes to or detracts from the general aim of the activity in a significant way” [1]. CIT involves a process of collecting observations of behavior and then classifying them so that they are useful in addressing practical problems [24]. The goal of CIT is to make respondent data useful for answering the research questions while sacrificing little detail and comprehensiveness as possible. Additionally, CIT is a qualitative procedure which faceplates the exploring of significant occurrences (events, incidents or special issues) defined by individual respondents toward the core perspective of individual cognitive, affective and behavioral elements [25].
Data Collection Procedures

Purposive sampling method was applied to collect participants. We selected critical cases on the basis that they have experienced some service in Taiwan and then somehow expressed the experience to their friends/relatives. Finally, seventy participants were chosen to one-by-one took part in our semi-structured interviews during three months of October, November and December in 2010. Semi-structured approach was used because interviewers enable a facilitator to enter participants’ realities and collect their interpretations, which are crucial to understanding WOM. As such, semi-structured approach is a way to get “in tune” with consumers or, more accurately, with consumers’ realities [26]. Interviewees were recalled to their recent talks/expression on certain services in the past six months, and then shared with us particular incidents which were mentioned during WOM.

To be included in the study, an incident needs to meet certain criteria. Each incident had to be (1) related to a certain service in Taiwan, (2) experienced by interviewees, and (3) talked/shared to other interviewees’ friends/relatives by any way such as face-to-face, telephone or internet.

Questionnaire Development

Prior to the final data collection, a pilot study was conducted with ten participants from the target population as foreigners in Taiwan in order to check the quality of the questions and generally concentrate on often-used services. We realized some misunderstandings of critical questions for interviewees, and therefore, some questions were modified and clarified. The data of this pilot study – undertaken to gather additional information with respect to our literature review – also strengthened most of our convictions concerning the relevance of WOM experiences from consumers’ (givers’) perspective. Also, healthcare, convenient store, restaurant, transportation, banking, and education are common services which international students often reach.

In order to avoid a problem of interviewees’ dim memory, in the final stage of data collection, we started interviewing with some ‘warming up’ questions and asked participants to share with us their own experience on the service they used. After that, we directed them to whom and what they talked/shared that experience to (refer Appendix 1). The researchers take responsibility for abstraction and inference.

DATA QUALITY

Sample Validation

Since multiple interviewers took part in data collection, validation was needed to overcome the possibility of data inconsistency. After completing all the interviews, the participants were randomly selected by the researcher to (1) validate the responses that were given during the interview (2) to identify the service in the WOM.

Sample Characteristics

Demographically, 36% of participants are female and 64% are male. The entire study sample was well educated with the majority having a bachelor’s degree and 30% completing a graduate degree. Participants mostly ranged in age from 20 to 30 years, and come from 25 countries (Australia, Bolivia, Cambodia, Canada, Colombia, Germany, Hong Kong, India, Indonesia, Malaysia, Mexico, Mongolia, Myanmar, New Zealand, Norway, Panama, Peru, Philippines, Poland, Russia, South Africa, South Korea, Thailand, United Kingdom, Vietnam). The largest number of participants talked about service in transportation (36%), and convenient store (29%). The same amount of 14% mentioned service in restaurant and healthcare (hospital). Banking service was shared by the rest of participants (7%).

DATA ANALYSIS

Unit of Analysis

The term “critical incident” can refer to either the overall story or to discrete behaviors contained within the story, therefore, the first step in the data analysis is to determine the appropriate unit of analysis. In our study, we decided to use the description of the overall story as better suited in preserving the specificity of the data. For example, a critical incident that describes “I think they are friendly, I don’t speak Chinese, but they help me” is coded as “friendliness” instead of “language”.

Incident Classification

After the data collection, the incident classification system of the CIT was used to categorize the incidents. The main goal in the categorization process is to make the data useful for answering the research questions while sacrificing as little detail as possible. The analysis typically focuses on the classification of reports by assigning incidents into categories to explain events using a content analysis approach [27]. Content analysis takes the communications that people have produced and asks questions of the communications [28].

Subsequently after the process of repeated, careful readings and sorting of incidents by the researchers, the similarities among the incidents begin to become apparent. Two judges independently developed mutual exclusive and exhaustive for 285 critical incidents. To be consistent with previous studies employing the CIT in the marketing domain, the intrajudge rater was used [27]. Intrajudge reliability was used to examine the same judges classified the same phenomenon into the same class of categories and its sub-categories. When intrajudge reliability exceeded the .80 cutoff, both the judges will conduct a comparison of their categorization schemas and resolved any disagreement. Finally, a third judge was used to conduct a final sorting on the categories. The final interjudge reliability was very satisfactory (0.95 cutoff).

RESULTS AND ANALYSIS

INCIDENT STATISTICS

Categories and hierarchical subcategories are discussed in detail subsequently. Table 1 shows the classification scheme from the 285 critical incidents. The ratio of positive and negative incidents is illustrated in Table 2.

The 11th International DSI and the 16th APDSI Joint Meeting, Taipei, Taiwan, July 12 – 16, 2011, pp.26-34
CLASSIFICATION DATA

Physical Environment

Physical environment refers to the general characteristics of the organizational facility, ambience and functional characteristics of the organizational structures such as organization of space that premises for people stay [29]. Defined in this way, in our study, the physical environment is understood as practices of comfort, cleanliness and convenience of the organizational environment which is perceived by the customers [30].

The “physical environment” category in this study included all the critical incidents of WOM that involved clean service environment, comfortable service conditions, service or product facilities, ease of use and convenience conditions. The physical environment was the largest WOM category, mentioned by 40% of all incidents. Its subcategories included cleanliness, comfort, and convenience. Four percent of participants mentioned cleanliness as one of the physical environment factors for WOM, 18% of the incidents relate comfort issues and an additional 18% mentioned convenience of service in the WOM. In the “cleanliness” subcategory, most of the study participants mentioned as saying positively in their WOM. For instance in transportation service, “There seems no dust in high speed train in Taiwan, like in flight”, or “The buses are very clean with a separated toilet inside”; in hospital, “I feel very clean in this hospital, its disinfection system is really organized and easily used”; in restaurant, “It’s quite fine with me, everything in that restaurant looks clean up”.

In the second subcategory, the participants talked about positive and negative “comfort” service environment. The participants were found sharing positive “comfort” in WOM about the service in restaurant, transportation, hospital, and convenient store. For example, customers felt that “The high speed train feels new compare to the normal and comfortable, new train style, different view and different system…on the train it also provides you information about the weather, the speed of the train”. Moreover, the participants also talked positively about “comfort” in the WOM with the convenient store services (“You can sit in front of 7-11 and drink, talk, eat…they prepare some chairs and tables there…so great when you have a drink with your friends, you can get beer right after you finish, bottle then bottle, as much as you can drink, then talk as much as you can, stay there as long as you can”). In contrast, five interviewees said negatively about “comfort” on healthcare service and restaurant in the WOM. For instance, the respondent reported “I found the room in hospital near the elevator, oh, so noisy”; or “I told my classmates that I really hate Taiwanese blowing their noses in restaurant, I am having my lunch and a very big crazy sound from nose cut off my enjoy. Many times like that”.

<table>
<thead>
<tr>
<th>WOM Category</th>
<th>N of Critical Incidents</th>
<th>% of Critical Incidents</th>
<th>Services &amp; Incidents (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Environment</td>
<td>114</td>
<td>40%</td>
<td>T(2%), H(1%), R(1%)</td>
</tr>
<tr>
<td>a. Cleanness</td>
<td>12</td>
<td>4%</td>
<td>T(6), H(4), R(2), C(6)</td>
</tr>
<tr>
<td>b. Comfort</td>
<td>51</td>
<td>18%</td>
<td>T(6), H(2), R(3), C(7)</td>
</tr>
<tr>
<td>c. Convenience</td>
<td>51</td>
<td>18%</td>
<td>T(6), H(2), R(3), C(7)</td>
</tr>
<tr>
<td>Employee Attitude/Behavior</td>
<td>99</td>
<td>35%</td>
<td>T(1), H(3)</td>
</tr>
<tr>
<td>a. Caring</td>
<td>12</td>
<td>4%</td>
<td>T(1), R(3), B(1)</td>
</tr>
<tr>
<td>b. Politeness</td>
<td>14</td>
<td>5%</td>
<td>T(3), H(5)</td>
</tr>
<tr>
<td>c. Responsiveness</td>
<td>23</td>
<td>8%</td>
<td>T(2), H(4), B(3)</td>
</tr>
<tr>
<td>d. Language</td>
<td>25</td>
<td>9%</td>
<td>T(2), H(2), R(3), C(2)</td>
</tr>
<tr>
<td>e. Friendliness</td>
<td>25</td>
<td>9%</td>
<td>T(2), H(2), R(3), C(2)</td>
</tr>
<tr>
<td>Value</td>
<td>46</td>
<td>16%</td>
<td>T(4), H(2), R(4), C(2)</td>
</tr>
<tr>
<td>a. Pricing</td>
<td>34</td>
<td>12%</td>
<td>H(1), B(3)</td>
</tr>
<tr>
<td>b. Timing</td>
<td>12</td>
<td>4%</td>
<td>H(1), B(3)</td>
</tr>
<tr>
<td>Functionality</td>
<td>25</td>
<td>9%</td>
<td>T(1), H(1), R(1.5), C(0.5)</td>
</tr>
<tr>
<td>a. Quality</td>
<td>12</td>
<td>4%</td>
<td>T(1), H(1), R(1.5), C(0.5)</td>
</tr>
<tr>
<td>b. Comparison</td>
<td>13</td>
<td>5%</td>
<td>T(2), H(1.5), B(1.5)</td>
</tr>
<tr>
<td>Total</td>
<td>285</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

Note: T = transportation, H = healthcare, R = restaurant, C = convenience store, B = banking

TABLE 1. INCIDENTS CLASSIFICATION
Finally, in the third subcategory, most of the study participants expressed positively about “convenience” during WOM. For example, “Its good service and truly convenient [7-11]…it opens 24 hours, so flexibility of time and you can get something any time”, “there are so many convenience stores around here, 7-11, Family Mart, so on, and 24 hours for you”; “the bus is also 24 hours, anytime for you, you can check their schedule and book tickets online, you never have to wait for long time”. On the other hand, the same participant had a dissatisfied experience with the healthcare service in Taiwan also talked negatively about “convenience” during his recent conversation (“Emergency process is very slow in the hospital…I think that they do not put enough people…in one ward have 1 doctor and two nurses…so this is not enough”).

Service Employee Attitude/Behavior

Service employee attitude refers to such issues as affinity to be in contact with the customers and understanding of the importance of customer for the individual and the company’s performance. Service employee behavior is defined as the ability of the service employee to help their customers by engaging in behaviors that increase customer satisfaction [31].

Service employee behavior/attitude was the second largest category of WOM, mentioned by 35% of all incidents. It included all critical incidents that were either positively or negatively related with employee attitude, willing to help needs, language skills and friendly behaviors with the service itself. As for the present study, the employee attitude/behavior is presented into five subcategories of caring, politeness, responsiveness, language, and friendliness.

Most of the participants described the employee’s responsiveness, language skills, and friendly behavior. Employees’ caring and polite attitude were also important factors that were mentioned during WOM, which is accounted by 4% and 5% incidents respectively.

“Caring” was described as helpful attitude of the employee, and was positively communicated in the WOM. The following description of story is an example of positive “caring” --“So, the staff [HRS] is really helpful…there is one time, I have very big luggage… I try to sleep, but cannot sleep because of my big luggage…I think the waiter, she just walk around and sees me, and help me to put my luggage at the other end of the cabin so that I can have comfortable space”.

A second subcategory of employee attitude/behavior is “politeness” which was described by participants as sense of respect (“I feel like they [restaurant waiter/waitress] pay more respect to me”), the employee’s willingness to help (“The attitude of waiter/waitress is good…always smile…when we had questions, they answered”). On the contrary, the participant mentioned “rude” as the source of negative “politeness” in their WOM (“I got a wrong number in line twice because I could not understand Chinese, and the staff [banking] did not help to explain to me, just refused to serve me twice, stared at me and spoke in Chinese…I feel he was a bit rude”).

**TABLE 2. RATIO OF POSITIVE AND NEGATIVE INCIDENTS**

<table>
<thead>
<tr>
<th>WOM Category (100%)</th>
<th>Positive Incidents (%)</th>
<th>Negative Incidents (services)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Environment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Cleanness</td>
<td>100%</td>
<td>0</td>
</tr>
<tr>
<td>b. Comfort</td>
<td>90%</td>
<td>10% (H &amp; R)</td>
</tr>
<tr>
<td>c. Convenience</td>
<td>91%</td>
<td>9% (H)</td>
</tr>
<tr>
<td>Employee Attitude/Behavior</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Caring</td>
<td>100%</td>
<td>0</td>
</tr>
<tr>
<td>b. Politeness</td>
<td>75%</td>
<td>25% (B)</td>
</tr>
<tr>
<td>c. Responsiveness</td>
<td>80%</td>
<td>20% (H)</td>
</tr>
<tr>
<td>d. Language</td>
<td>80%</td>
<td>20% (B)</td>
</tr>
<tr>
<td>e. Friendliness</td>
<td>100%</td>
<td>0</td>
</tr>
<tr>
<td>Value</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Pricing</td>
<td>71%</td>
<td>20% (C)</td>
</tr>
<tr>
<td>b. Timing</td>
<td>0</td>
<td>100% (H, B)</td>
</tr>
<tr>
<td>Functionality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Quality</td>
<td>100%</td>
<td>0</td>
</tr>
<tr>
<td>b. Comparison</td>
<td>75%</td>
<td>25% (B)</td>
</tr>
</tbody>
</table>

Note: T = transportation, H = healthcare, R = restaurant, C = convenience store, B = banking

The 11th International DSI and the 16th APDSI Joint Meeting, Taipei, Taiwan, July 12 – 16, 2011, pp.26-34
The third subcategory included service employee’s “responsiveness”, mentioned by 8% of incidents. Responsiveness was described as quickness (“How quickly they [doctors] are, what type of service they offer and do”), and familiarity with the customers (“They [restaurant staffs] are familiar with me and already know what I want...so it is good”). This subcategory also included negative “responsiveness” that described a slow service (“Some nurses are really kind and helpful...but some, we just call but they did not come”), and unhelpful (“The doctor has a good English, he also made jokes and was confident...but after words I didn’t feel favorable, since he didn’t give me enough explanations”).

The fourth subcategory also accounting 9% of incidents, the “language” of the service employees was described as foreign language ability, especially English (“I also found the staffs at the station are also very helpful...most of them can speak English” or “It’s great when they have nurses who can speak English, we can communicate better...it’s acceptable”). On the other hand, the participants were found to mention negatively on “language” in their WOM about the lack of employee ability to offer assistance in English (“I think because of the language problem; I think most of the staff [banking] could not speak English”).

The last subcategory is “friendliness” accounting 9% from the total incidents. This subcategory covers a wide variety of expressions of friendliness that may be conveyed through either verbal or gestural means. Included are such activities as welcoming, greeting, waving hello or goodbye (“Staffs often say ‘welcome’ when you enter the store...how to say in Chinese? Oh, ‘Huan Ying’...then, when you leave, they say ‘Man Zou’, I think it means ‘walk slowly’, it’s nice”), smiling at someone (“I think they generally just put a smile on everyone...they try to be as friendly as possible, because you’re in hospital”), sympathizing with or conversation with customers (“They are very friendly...they start their conversation like ‘how are you or we haven’t seen each other for a while’ something like that”), and helping (“I think they are friendly...I don’t speak Chinese, but they help me”). Perhaps, since all of these incidents were expressed about the staffs; there is tendency for these various behaviors as being a deliberate, purposeful attempt on the part of one character to express friendliness toward customers. Therefore, this may eventuate in some pleasant outcome for the person receiving the friendliness.

Value

Value of a product/service within the context of marketing means the relationship between the consumer's expectations of product/service quality to the actual amount paid for it. It is often expressed as the ratio between perceived benefits and perceived price [32]; or the customers overall judgment of what is received and what is given [33]. Thus, the value is formed by a positive, contributing part and a negative, deducing part.

From the data analysis, most of the benefits that a customer will be received are mainly intangible, which may imply about the environment or employee behavior. Through their WOM, majority of the study participants mentioned about the value of the services as related with the pricing and time.

All critical words involving prices, rates, fees, charges were included in the "pricing" category. Pricing was the third largest WOM subcategory with 12% of all incidents, and accounted for 74% of the value incidents. Because our participants are foreigners in Taiwan, some of them made comparison with that in their home country and all defined that the service pricing is cheap in Taiwan (“Compare to US, it [hospital fee] is a lot cheaper here”). Moreover, when they mentioned about “cheap”, they often imply a comparison with other same service or with what they received (“The price [in low class restaurant] is quite cheap, just 60NT, you can have a good meal with friendly service” or “Even thought price [in convenient store] is a bit more expensive than in supermarket, but you can have it any time” or “they have good services and facilities [bus], it’s fair for me to pay that kind of price”). We notice that it is quite difficult for a participant to recall about the price of the particular service. Therefore, by making a comparison with their home country seems to be the most feasible and best option in expressing their perception.

Regarding to “time”, all incidents are related to time-consuming for service using. Four participants talked negatively about how long they have waited in the healthcare service (“When we went to register, there were two or three persons...they said ‘okay, wait’, then we did register first...and after that, wait, wait around 20 minutes”, or “I have to wait at least one hour...I think one hour, for me, is a little bit long time”), and in the banking service (“The service is time-consuming”).

Functionality

Functionality refers to the degree to which the fitness between customer expectations and quality of service facilities [34]. The results in our survey show that most of participants referred to product quality, and again, made comparison during in the WOM. Two subcategory of functionality is “quality” and “comparison”.

If a product fulfils the customer’s expectations, the customer will be pleased and consider that the product is of acceptable or even high quality. If his or her expectations are not fulfilled, the customer will consider that the product is of low quality. This means that the quality of a product may be defined as “its ability to fulfill the customer’s needs and expectations”. Most of incidents on product quality are about food. Some described positively about “quality” of restaurant in the WOM (“The service over there is good and the food is good...not too salty”), in the convenient store (“I bought a new flavor of Dorito and shared with my friends...these chips are dank...they actually taste like ‘ribs’...the chips were really good”).
Five percent incidents regard comparison on customer expectations and the service facilities. Some WOM compared different qualities in a healthcare service (“It is good because it provides the good medicine… I often go to the national Cheng Kung hospital, and I also go to outside clinics…I think the quality of medicine is better than outside”). The rest took the service in their home country to compare with what they received in Taiwan. Positive comparison for transportation in Taiwan mentioned “Transportation service is much better than my country…when I take a bus to Kaohsiung or other cities; the bus often departs to those cities every 30 minutes”. However, when talking about banking service, two participants expressed their negative WOM on how complicated it is. For example, “I think the banking service in Taiwan is complicated compared to my country. It’s just easy, you just put the money and you can get the full amount on the same day”.

DISCUSSION AND CONCLUSION

The objective of the present study is to identify and develop dimensions of foreigners’ WOM in relation to the service industries in Taiwan. An articulation of rigorous classification on the 285 critical incidents provides the fundamental first step in developing a comprehensive understanding of foreign consumers’ WOM. Specifically, four main groups including (1) physical environment, (2) employee attitude/behavior, (3) value, and (4) functionality were identified as the main incidents uttered by these consumers during the WOM.

In general, we found most of the study participants were more likely to mention positive arguments during the WOM. This is somewhat unorthodox with the conventional ideas of WOM, implying that people are less of reporting negatively during WOM [7]. Previous studies indicate employee actions [1] and core service failure [2] are both important determinants of satisfaction and dissatisfaction in the service industry. As for the present study, physical environment was found to be considered as the most influential predictor of consumer satisfaction/dissatisfaction on service industry in Taiwan. In particular, the foreign consumers are found to attribute the convenience and comfort of the service as the most important indicator of their satisfaction or dissatisfaction. Perhaps, given to the intercultural differences, the foreign consumers are likely to be less technical and more favorable by expanding their zone of tolerance [9]. Pricing is the third most important factor mentioned by the foreign consumers during the WOM. And majority of the participants uttered positively about the pricing during the WOM. However, many of them were having difficulty to explicitly recall the amount paid for the particular service. Instead, inference was commonly made by making comparison with their home country.

An equal importance in the WOM is the employee attitude/behavior, mentioned by 35% of the incidents. Specifically, the employee friendliness, language skill and responsiveness were frequently uttered by the sample participants during the WOM. Not being familiarized with the local standard, it may be difficult for the participants in assessing the quality tangibly. Therefore, the attitude/behavior of employees was considered to be the next most feasible interpretation of service quality. The last two categories mostly uttered were value and functionality.

Besides of above discussion and implication, some limitations, however, should be acknowledged in our study. First, the number of data collected in the present study was numerical small; thus, diminishing the possibility for generalization in a wider scale. Second, since most of the participants are international students in the Taiwan’s local universities, it is also likely that their consumption will be limited on everyday necessity (e.g. convenience store, banking service, restaurant, or the healthcare service). Therefore, how other services such as high class restaurant and hotel being rated offer another opportunity for future research to investigate.

ACKNOWLEDGE

The authors would like to express our sincere thanks to Mr. Mohd Rizal Abd. Hamid and Ms. Odonchimeg Myagmarsuren for their help in this study.

APPENDIX

Appendix I: Study Interview Guidelines

Have you ever had any experience with on any of these services in Taiwan in the past 6 months?
1. Education services (e.g. NCKU)
2. Health Care Services
3. Telephone services
4. Banking
5. Post-office
6. Transportations (e.g. Taxi, Train, Bus and Airport)
7. Restaurant
8. Convenient store (e.g. 7-11, Family-Mart)
9. Others

1. Can you share with us your experiences with that service? Please think of the most recent time that you were in conversation and sharing/discussing/talking with your friends/family about you experience with Taiwan services?
2. Have you talked about this experience afterward to anyone?
3. What did you talk during the conversation?
4. How did this conversation happen?

Appendix II: A Sample of Interview Description

WOM01
Date: December, 2010, Friday, 6:20pm-6:50pm
Place: Meeting Room, College of Management, NCKU
Interviewee: 01

*The researcher explained the confidentiality and requested the participant permission to tape the conversation and to take some time and review the question sheet before starting the interview.
As you can see from the sheet there are list of services. Have you ever had any of these services in the past 6 months?
Yes, for most of the services.
Do you think, most of these experiences favorable or unfavorable for you?
I will say most of it favorable, only one of it unfavorable.
Can you share with us your experience with that service?
I had an experience with the healthcare service in NCKU. I was there in the hospital before. The doctors and the staff, they are just wonderful.
[Probe] Is there anything else? For instance, how about the language for communication with the medical staff?
I actually speak Chinese, so that is not big of an issue. But, most of the time, many of the nurses and doctors will speak English. Come up straight to me and speak in English, and I said something in Chinese, and then we go in Chinese.
[Probe] How about the price here compare to in the US? It considerably cheaper, in US it so expensive it can cost you to go bankrupt, if you don’t have proper health insurance. Even for small…
[Probe] Specifically, how cheap is that and how much do pay for that? Typical doctor in US for random check up can be 10000NTD. It depends…weight, the height, diabetes, eyesight, STD. There more test that you what the more complete the more cost. It is not cheap at all.
[Probe] How about Taiwan?
You are covered by NHI, and compare to US, it is a lot cheaper here.
[Probe] How about the general environment?
It’s fine. I like the set-up in the hospital. There are two different wards—one for serious issue. What other ER issues are taking on other.
[Probe] Do you think it is manage properly? In term of when you first arrived at the hospital. Do you think they give you proper treatment and proper service?
I think the treatment and service is fine, what you would have expected….I hope, for my case it is fine. But, just based on one time, I think yes. Other than that I’m not qualified. I haven’t had any chance of talking with the management. From what I saw, everything is fine. I give it a 5 out of 5.
Do you talked about this experience afterward to anyone?
Yes. I talked to my classmates and family about this, about the healthcare. I was in the hospital this summer. I let them know about the quality of healthcare in Taiwan and the quality of the health insurance.
[Probe] So, you talked with your family and classmates about the healthcare in Taiwan?
Yes. The healthcare is the big issue.
So, what did you said during your conversation?
For the healthcare it was about the quality of the doctors and care. How quickly they are, what type of service they offer and do. For instance, with the general health insurance and social wise health insurance, you not usually put in a private room; unlike in the US you always have a private room, or in a room with another person. Where in here, it is not anything serious, you will be put in the general room with other people. And the types of medicine and how the doctor responded.
[Probe] What do you mean by the doctor responded?
How they treated you, what they did and how they diagnose.

All these were slightly different. Even though most of them study abroad, they have different ways to diagnose and give different medication. I’m not sure if you are aware of that, for instance, if you break a bone, in my part of the world they give you stronger medication for pain. Over here, they give something like “Tyanol” or “Profane” is considered strong. For us, we used it on typically daily basis for most people. The different in medication level, there is a lower tolerance for medication…”Tyanol” and “profane” works better for you, but for most people in the west we have higher pressure. That probably a bad thing, but we won’t go into that.
[Probe] Besides talking about the healthcare and the doctors, do you have anything else that you said in your conversation?
A lot about the restaurants and the foods, it’s so different from the US. Some of it similar but for the most part is dissimilar.
My family and friends in US are curious how the foods is and all the things that you eat in daily basis.
[Probe] Return to the healthcare service, you talked about the doctors. Did you talk to their classmates and family about the doctor attitude? Or the way that treat you?
Yes, of course, they also asked me. The way they issue work here is slightly different…the hierarchy. Generally the doctors may see you just initially once, and after that will issue it to the nurse. In the US, the doctor will come many times throughout a day or weeks, depending on what situation you are in. So, I talked about that and how that different…
[Probe] You also mentioned about the nurse, what do you mean by that?
Not bad.
[Probe] What do you mean by not bad?
The nurses are really nice.
[Probe] How nice? Do they smile to you or treat you special way?
I don’t think it’s anything special; I think they generally just put a smile on everyone. They try to be as friendly as possible, because you in hospital. Who wanted to be in the hospital? They try to make you stay enjoyable.
And lastly, could you tell us how did this conversation happen?
Well for my classmates, most of it face-to-face. Unless I was specifically talking to my family in the US, I used the Internet (MSN, Skype, facebook).

Demographic Profile
Gender : Male Age: 26
Income : Below NTD30000
Occupation : Student Country : USA
Education : Postgraduate
Purpose of visiting/living in Taiwan: Studying at the IMBA and learning Mandarin.

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Journal of Economic Psychology

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inter [9]


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THE STUDY OF CLOUD COMPUTING ON SERVICE INNOVATION

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ABSTRACT

Cloud computing brought a significant change to internet generation; it can feel the dramatic impact from the upstream of industry chin to consumers. This study is according to the service dominant logic and the characteristics of cloud computing, and attempt to explore the antecedents of cloud computing adoption for companies, and then make an impact on the service innovation performance. We proposed four construct that contain the relationship conditions between cloud computing suppliers are reliability and compatibility, and the customer orientation and cost plan to themselves. After the measure value of PLS path model, we found that reliability, compatibility, and cost have significant impact on cloud computing adoption. We expect this study will provide to cloud computing providers as a reference, and have a broad understanding with the cognition of their consumers.

Keywords: cloud computing, service-dominant (S-D) logic, service innovation, mediating effect

1. INTRODUCTION

1.1 Research Background and Motivations

High-tech industry in Taiwan has developed more than twenty years; especially the information technology industry that is one of the important roles in global supply chain. However, cloud computing creates a new wave of competitive situation. Cloud computing offers challenges and opportunities to this industry that how to enhance competitiveness form hardware manufacturing transition to brand, profits, and soft power. Although cloud computing is not a new technology, it stirs up software and service-based new competition and it will reshape the value chain of IT industry. The most opportunity for developing cloud computing is the innovation of software and application service, it can build through the existing hardware manufacturing strength and foundation, and form the low-cost and differentiation strategy to improve their margins and output value.

Cloud computing allows computer technology to be easily accessed as a service over Internet or via a private network from any location, so that computer technology, software program, and data can be available when and where the users need them. Market Research Company Gartner predict that by 2012, there will be 80% of the 1,000 large enterprises of “Fortune” will adopt the cloud computing service which become one major part of IT application environments. This research would like to discuss that the adoption situation of cloud computing service in Taiwan.

1.2 Research objectives

Based on the background and motivations above mentioned, we tend to explore the following objectives: (1) clarifying the cloud computing adoption antecedents and the interorganizational relationship; (2) exploring the relationship between cloud computing adoption and service innovation performance; (3) examining the mediating effect among adoption antecedents and service innovation performance.

2. LITERATURE REVIEW

The critical discuss point in our research is the antecedents of information technology adoption. Therefore, we can separate two parts in information technology generally, one is individual level and another is firm level. In individual level, researchers always discuss the reasons, which would affect users to adopt, such as the support of organization, characteristics of system, and satisfaction of users. In firm level, scholars often research which reasons will affect whole organizations cognitive to the antecedents of information technology adoption, such as, whether a new information technology can increase operating value, create competitive advantage, enhance core competence and improve the misunderstanding of department or organization. In addition, in this study, we discuss the IT adoption that just focuses on firm level. In addition, we will discuss the influence of service innovation for company itself after adopting cloud computing.

2.1 Cloud Computing

The term “cloud computing” has caught fire and is used in a variety of contexts in advertising and the media. The related researches of cloud computing are rare recently, one of the research team that proposed some opinions (1) the positioning of cloud computing of computing systems, (2) distinguish the difference of cloud computing, utility computing, and grid computing, (3) interpret the framework of cloud computing for market orientation, (4) development-related issue of cloud computing from service level agreement, (5) display the research about global cloud exchange market, (6) compare the existing cloud computing platforms, (7) compare the performance differences of Aneka cloud computing, high performance computing (HPC), and internet- based service, (8) understand global cloud exchange market from the service quality viewpoint, (9) propose the subjects about third party partners in cloud storage service.

Lyde and Gilbert [6] address that cloud computing could make continuously cost down and improve efficiency, but it has some legal and practice risk probably, such as data...
protection act, confidentiality, and database right. In addition to, about the cost benefit, "usage-based pricing” is hours purchased via cloud computing can be distributed non-uniformately in time, and have no questions of software update for users that enhance the efficiency of resource use [4].

This study measures the extent of cloud computing are according to following three categories. The Commerce Department’s National Institute of Standards and Technology (NIST, 2010) has attempted to provide structure to the cloud computing conversation with some helpful definitions. NIST defines three basic types of service models for cloud computing:

1. **Infrastructure as a Service (IaaS),** involving the provisioning of fundamental computer resources (e.g., processing, storage, networks);

2. **Platform as a Service (PaaS),** involving the provision to users of the capability to deploy onto the cloud infrastructure applications created by the user with provider-supported programming languages and tools; and

3. **Software as a Service (SaaS),** involving access to a provider’s software applications running on a cloud infrastructure.

In this research, cloud computing will defined as that companies get computing capability, storage space, software application, and data which through internet from a huge data center of cloud computing service supplier through internet [12].

### 2.2 IT Adoption

Because of the rapid development of information technology, most of companies introduce the IT for enterprise reengineering to maintain or improve competitive advantage. Literature in the field of information management has been widely appreciated that the adoption of information technology can help companies to create competitive advantage [13]. Information technology is a very broad concept, in this study; information technology is defined according to Straub and Wetherbe [19] as “IT is a new technology which involves hardware, software, database, and communication, and adds the new concept of information system application, such as CAD/CAM. Organization introduces information technology that often also regarded as a kind of organizational innovation.

Based on the model of Kwon and Zmud [22], “adopt” is defined as a resource investment decisions that in order to meet the changes required. It has to determine hardware and software investment in equipment and personnel appointment system at this stage. So it might easily lead to failure and waste of corporate resources, if they failed to consider in detail for the important factors, put huge amounts of money and introduce the information technology, Ryan and Gross [32] defined adopt as the first use. Lionberger [22] thought that adopt is decided to use a new thing, but not bound to continue to use. Rogers [30] considered adopt is a decision that continued to use and use an innovation thing. Because IT adoption has occurred over time, firms may have decided to use it for different reasons. For example, firms that adopted early may have recognized the benefits sooner, and may have seen the IT as a way to gain competitive advantage. However, theory indicates that, as time goes by, an organizing vision or focal community idea for the application of IT in organizations’ is formed [13]. As a larger number of firms adopt a technology, the technology becomes legitimized, and rather than asking “why do it”, firms begin to ask “who is doing it” and “why do it”. Later adopters may place less emphasis on perceived benefits and compatibility of the technology and develop a IT largely in order not to be left behind other firms in their industry. Because IT adoption has occurred over time, firms may have decided to use it for different reasons. For example, firms that adopted early may have recognized the benefits sooner, and may have seen the IT as a way to gain competitive advantage. However, theory indicates that, as time goes by, an organizing vision or focal community idea for the application of IT in organizations’ is formed.

### 2.3 Service Dominant Logic (S-D Logic)

Service dominant logic provides a new service-centric concept that is customer oriented and relational [34]. Although this transforming viewpoint of marketing, Vargo and Lusch exhibited that the firm should emphasizes on the intangible resource, mutual relationship and co-creating value to transform marketing concept. Furthermore, service offering has replaced of the tangible offering to become the basis of value exchange.

The discrimination between product and service getting more and more blurred. Since value is always co-created with and determined by the customer (value-in-use), it cannot be embedded in the manufacturing process. The comprehension of customer is easily influenced by additional service, and not only by the product itself which they bought. Ever since a product or service of what customers really pay for is the value of service provided, the company needs to change their positioning view form producer to customer.

Vargo and Lusch [34,35] used nine foundational premises (FPs) to present their emerging dominant logic. Furthermore, they address the foundational premises (FPs) of S-D logic inform a “competing through service” strategy from G-D logic and thus allow for the development of nine derivative propositions addressing competing through service [33]. Their overall theme is that applied collaboration and knowledge are the key drivers for firms to more successfully compete through service. To complete this successfully, the firm must view external environment, partner, and customers as operant resources. Most importantly, at the beginning of FP1, Vargo and Lusch [34] claim that “the application of specialized skills and knowledge is the fundamental unit of exchange,” which means the resources are the main factor for the firm to create new value and competitive advantage. Additionally, resources can be separated to “operand resource” and “operant resource” [34, 35]. Operant resource can be defined as “resources on which an operation or act is performed to produce an effect,” on the contrary, operant resources as “which are employed to act on operand resources.” That is to say, operant resource becomes the
ingredient of operant resource which is the main factor of firm’s competitive advantage. Even the great OEM supplier of notebook and server in Taiwan — Quanta have claimed that they are service industry, no longer manufacturing industry. Lusch and Vargo [34] had suggested that service should not be defined as in or out of the boundary of manufacturing activities. In contrast, the role of service economic activities is achieving importance in the world, many manufacturing companies inform the position to view themselves as a service provider, and regard the intangibility of product as something to enlarge the value of product. What is more, the definition of service refers to the application of specialized competences (knowledge and skills) through deeds, processes, and performances of the benefit of another entity or the entity itself [34].

In addition, the role of skills and knowledge are more important in the value creating process. In the S-D logic, knowledge and skills belong to operant resource. Compare to operand resource, they usually are intangible and invisible. Company uses their operant resources to provides direct service for customer and in return, customers use more their own operant resources to act with the resources which provided by the company in the process. Thus, all the values are integration of operant resources regardless it is invested from company or customers.

Base on the discussion above, we realized another point of service-dominant logic is the role of customers. In the proportions of Vargo and Lusch [34], they mentioned about that company should view their customers as a co-producer instead of value receivers. Traditionally, price represents the value of product (value-in-change), however, in S-D logic, the value that customers received is created by themselves (value-in-use).

Based on S-D logic, company needs to change its view of value creation. Company can only make value propositions [34], and what they need to do is involving the operant resources they collected and reassemble the value.

According to above mentioned, we can understand that operant resources play a very important role in service-dominant logic, and they suggested company can acquire more resources both from inter- and out of organization. Nevertheless, previous researches mentioned a little about the impact on the role of capability within service-dominant logic. Therefore, we are going to develop our study based on this theory and focus more on the role of operant resources that is antecedents of IT adoption. And considerate that a firm whether according to the concept of operant resources to adopt cloud computing.

2.4 Service

We all know that there are four important features, involving intangibility, inseparability, heterogeneity, and perish ability [23]. Compared to the usual tangible product, service is dynamic and performs through gathering continual events and steps during a period. Biner also suggested the importance of service experiences. They mentioned that all of the employees in the company should focus on the same purpose- create an integrated, memorable and enjoyable customer experience.

The definition of services is no longer the activities beside the manufacture. Instead, it is the application of specialized competences (knowledge and skills) through deeds, processes, and performances for the benefit of another entity or the entity itself. Organizations should co-produce with their customers and see their customers as one of service providers to gain the information and skills through the process of co-production.

2.5 Service Innovation

Service innovation can provide two types of new solutions to customers: one involves combining new issues or concepts to form new solutions, and is broken down into improvement innovation and radical innovation; the other involves solving the same problem with greater efficiency, and can include the enhancement of productivity, suitability, or quality [8].

Managers tend to measure service innovation with financial standards or other quantifiable indicators such as sales figures and market shares. Voss, Johnston, Silvestro, Fitzgerald and Brignall [7] divide the performance measurement of service innovation into process and results performance measurement, which are described as follows. Researcher point out several characters: service outcome, competence and technology of service provider and customer’s competence [7]. In addition, Vere [25] mentioned that service innovation is not from single source, instead, the innovation comes from a collaborative network, which includes different employees with different competences, partners and supplier collaboration and the competence from combination of company and deliver technology. Any change in this network can produce new service. Moreover, based on this network model, they added the character of customer technology in the network and suggested that customer use different technology is also a kind of innovation.

The adoption of cloud computing was affect by above reasons. Furthermore, Vries [34] mentioned that service innovation is not from single source, instead, the innovation comes from a collaborative network, which includes different employees with different competences, partners and supplier collaboration and the competence from combination of company and deliver technology. Therefore, the action of cloud computing adoption can be regard as a way of cooperation. According to this definition, service innovation not only focuses on the innovation of service product but every activities or processes which can create new value are part of service innovation.

3. RESEARCH FRAMEWORK & PROPOSITIONS

3.1 Scale development

The survey targeted as three industry that are information technology, travel and tourism, and finance and bank industry in Taiwan. According to the information of Common Wealth Magazine and Digital Age, we selected information technology industry, travel and tourism industry, and finance and bank industry as our target industries. Furthermore, we based on the top five thousands largest corporations in Taiwan, which published by Chin Credit Information Service (2008) to seek out the firm list of above three industries. After that we filter target firms by search keywords with the name list to check which has
applied cloud computing. According to previous academic reviews, our questionnaire was revised and took pretests that based on the discussion with three scholars and three specialists of industry. Furthermore, for being more specific and appropriate to the research, many existing scale were modified and have been developed maturely to extend to each construct in the questionnaire. The information of assessment is from five-point Likert-type rating scales from 1 to 5, which 1 denote strongly disagree, and 5 is strongly agree to analyze the data.

A questionnaire survey approach was developed to investigate the technology adoption and the role of interorganizational relationship between cloud computing service supplier and adopters.

3.1 Reliability

Reliability defined as the degree that a positive trust relationship and represent the degree to which reliable partners are psychologically bonded [33]. It ordinarily gauges the strength of the relational ties [25]. In addition to, it's an interaction process which complementary assets are exchanged with external partners. Otherwise, information security is one of the most often-cited objections to cloud computing, most companies almost outsourcing payroll and many companies using external email services to hold sensitive information [26]. Reliability includes external ties, information security, and relationship with cloud computing suppliers.

One customer's bad behavior can affect the reputation of others using the same cloud. And legal issue is the question of transfer of legal liability—cloud computing providers would want customers to be liable and not those [24]. Selecting suitable and reliability partners achieve great partner's reliability. The relationship between a company and cloud computing suppliers are more reliable relationship, the extent of cloud computing adoption are higher. Because the more high-end cloud computing application, more related to the enterprise customer privacy information. Partners with high reliability are more likely to adopt cloud computing. Therefore, reliability is far more likely to be associated with increased involvement in adoption. Hence,

**P1: Reliability with cloud computing suppliers has positive effect on cloud computing adoption.**

3.2 Cost Considerations

Cost considerations can be defined as the expenditure of physical facilities and professional training for personnel in the long term. Lyde and Girbert [6] address that cloud computing could make continuously cost down and improve operating efficiency [25]. Cloud computing lets an organization pay by the hour for computing resources, potentially leading to cost savings even if the hourly rate to rent a machine from a cloud provider is higher than the rate to own one [19]. Besides, cloud computing is often described as “converting capital expenses to operating expenses” (CapEx to OpEx) which is a great incentive especially for SMEs, it equivalent to “pay as you go” that capture more economic benefit to the adopters. Hence,

**P2: Cost considerations have positive effect on cloud computing adoption.**

3.3 Compatibility

Compatibility is one of important facilitator for IT adoption [26]. We separate organizational compatibility and technical compatibility to discuss. Organizations are more likely to adopt a technology if they perceive that it is consistent with their culture, values and preferred work practices [30]. Because the adoption of cloud computing technologies often requires adopting firms to modify existing business practices and processes to gain benefits, organizational compatibility can impact the firm's adoption decision [17]. Besides, the extent to which IS innovation can be readily integrated into the firm’s existing IS environment is also important to the firm’s adoption decision. Incompatibility of an innovation with a firm’s existing software, hardware, telecommunications, or networking architecture may inhibit adoption [10]. Because cloud computing technology may require that organizations modify there is technical

![Fig. 1 Research Model](image-url)
infrastructure, organizations must assess the impact of cloud computing on current and future processing. So that IS managers are reluctant to involve their staff in cloud computing development, because they lack familiarity with a vision for this technology. Thus, technological incompatibility seems a more appropriate term for cloud computing can be readily integrated into the firm’s existing IS architecture may be more likely to rapidly adopt. So that according to above analysis, there is a positive relationship between organizational and technical compatibility with cloud computing adoption. Hence,

P3: Compatibility with cloud computing suppliers has positive effect on cloud computing adoption.

3.4 Customer Orientation

From S-D logic context, customer as an operant resource, which is a resource that is capable of acting on other resources, a collaborative partner who co-creates value with the firm. Customer orientation places the highest priority on the profitable creation and maintenance of superior customer value [20]. It emphasizes the need for the entire organization to acquire, disseminate, and respond to market intelligence from the firm’s target buyers and current and potential competitors. Some researchers suggest that market orientation is essentially customer orientation [6], representing the concept of “customer pull” in a firm’s strategic planning and implementation.

By prioritizing customers, a customer-oriented firm excels in its ability to seek and use market information to create and deliver superior customer value. Unlike a customer-led firm, which simply listens to its customers, a customer-oriented firm commits to understanding both the expressed and the latent needs of its customers [20]. We know that customers will expect a company provides some new service while the emergence of a new technology, and customer performance changed. So if a company pays attention to customer need, they will also want to use this technology and create new products or service. So we view customer orientation as an indicator to judge whether a firm pay attention to customer which is an operant resource. Hence,

P4: Customer orientation has positive effect on cloud computing adoption.

3.5 Service Innovation Performance

The adoption of cloud computing was affect by above reasons. And furthermore, Ordanini and Rubera [4] mentioned that service innovation is not from single source, instead, the innovation comes from a collaborative network, which includes different employees with different competences, partners and supplier collaboration and the competence from combination of company and deliver technology. We formulate the following hypothesis:

P5: Cloud computing adoption will be positively related to service innovation performance.

4. CONCLUSION

Because the adoption of cloud computing is not widespread in Taiwan, so some limitations of this study and can provide suggestions for future research. First, the adopters of firms of industries are particular, so it might not enough to represent the whole comments of Taiwanese firms. Second, service innovation performance might be changed overtime, because cloud computing adoption is initial stage in Taiwan. Third, try to use various dimensions to improve research model, even more, add the concept of time-based or S-curve to discuss the performance of different adopt phases of cloud computing in the future.

Besides, this study provides some management implication and contribution as following. First, this study provides some comments for cloud service suppliers that let them understand the considerations of cloud computing adopters, and improve their technologies based on these comments. Second, companies which would like to adopt cloud computing can assessing the effectiveness refer to adopters’ experiences through this study. Third, there is few studies related cloud computing in Taiwan, this study could be a reference for future research.

Some people think that technology boom is always one after another, cloud computing is just one of the cycle, and will eventually end in disappointment. International Research and consultancy (Gartner Inc.) claims that cloud computing technology has come to the maturity phrase of hype cycle that it had been placed great hope. Besides, the survey of Gartner also shows that, in a company, cloud computing are most likely one of the innovative behavior in the new year.

But in Taiwan, cloud computing is still at the initial stage now. In this study, we investigated the adoption antecedent and the relationship of adopter and supplier of cloud computing service, including reliability, cost, compatibility, and customer orientation, are combine the features of cloud computing and the constructs that used to be discussed in several researches of IT adoption.

In summary, the results of this study, we would like to discuss that if the qualities of relationship affect the extent of cloud computing adoption (SaaS, PaaS, and IaaS). Furthermore, we also probe into the influence of the extent of cloud computing adoption and service innovation performance. And this research provides a practice that let the adopter or supplier of cloud computing service to know the adoption antecedents of cloud computing impact on service innovation.

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INTERNATIONALIZATION – A LONGITUDINAL STUDY OF MALAYSIAN INTERNATIONAL FIRMS

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ABSTRACT

Empirical research on the internationalization strategies of international firms from emerging countries in Asia is limited. This paper examines and analyzes the internationalization strategies and characteristics of international firms from Malaysia based on a longitudinal study of five case firms. The findings indicate variations and changes in strategies during early and continued internationalization over the 11 year time studied. These findings and their research implications are examined and discussed.

Keywords: Internationalization strategies, longitudinal study.

INTRODUCTION

Much has been written about the multinational enterprises (MNEs) from the newly industrialized and industrializing economies, particularly from Asia [35][30][27]. Recently increased attention has been on foreign direct investment (FDI) and MNEs from other large emerging economies, such as the BRIC countries (Brazil, Russia, India and China; [42]. For example, considerable attention has been given to FDI from China [4][44]. However there is a dearth of research interest on internationalization of firms from the other developing countries. Internationalization of firms from other rapidly developing countries may be different and deserves more research attention. While the literature on MNEs from Asia and other emerging countries has grown considerably, full consensus on the theory and explanation of these firms has not emerged. Luo & Tung [27] advocate a springboard perspective to explain the unique features of MNEs from emerging markets, which include using international expansion to quickly acquire strategic resources and to reduce their institutional and market constraints at home. Similarly Buckley et al. [4] point out that the special explanations within the general theory of the MNE are required to explain Chinese overseas FDI. Hennart [18] highlights the need to consider the role of complementary local assets in internationalization theories. Further research, knowledge and data are required to fully understand the behaviour and dynamics of MNEs from Asian and other developing economies. In their paper, Luo & Tung [27] focuses their discussion of the springboard perspective on MNEs from the NIEs, and suggest that research be conducted on other emerging market MNEs. In fact, research on internationalization strategies from MNEs originating from other emerging economies in Asia is limited. Hence further empirical research on MNEs from other Asian countries will be instructive and fulfil an empirical gap. In particular, emphasis on the progress and continued internationalization of firms after their initial efforts seem to be neglected. Liesch et al. [25] and Melen & Nordman [32] points to this research gap in their studies of internationalization of firms.

This paper aims to contribute to this research area by presenting a longitudinal study of the internationalization strategies of five case studies of international firms from Malaysia, a rapidly developing country. This preliminary research paper examines the progress and continued internationalization of these case firms and analyse their strategies and success. A review of the relevant literature is followed by research methodology, findings and discussion. Implications for further research are also discussed.

BRIEF LITERATURE REVIEW

An explanation of the evolutionary and dynamic process of internationalization of a firm is provided by the Uppsala model [22][20]. This model of gradual incremental steps to international business expansion is based on a series of incremental decisions, whose successive steps of increasingly higher commitments are based on knowledge acquisition and learning about the foreign market. Foreign activity starts with export to a country via independent representatives/agents and is followed by the establishment of sales subsidiary and eventually production in the host country. The internationalization of the firm across many foreign markets is related to psychic distance (in terms of differences in language, education, business practices, culture and industrial development). Initial entry is aimed at a foreign market that is closer in terms of psychic distance, followed by subsequent entries into markets with greater psychic distances. In terms of entry mode and level of ownership, the incremental expansion of market commitment means that the initial entry is typically some form of low commitment mode (e.g., minority joint venture (JV)) and followed by progressively higher levels of commitment (e.g., majority JV and wholly owned subsidiary). Learning and knowledge acquisition provides the basis for greater overseas commitment. The learning and knowledge-based Uppsala model has received general support in empirical research [46][6][15] and its largely intuitive nature and evolutionary learning perspective lends itself to being an attractive explanatory model. Recently, Johanson and Vahlne [21] incorporate a network perspective to the model in which internationalization also involves the reduction of the liability of being an outsider in the relevant business networks (e.g., cross-country business networks). In the internationalization area, other researchers have applied or extended the learning perspective to different

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types of knowledge acquisition (e.g., [1]), accelerated internationalization of firms (e.g., [32][45]) and networks (e.g., [51][11]).

Another popular approach to explain the international expansion of firms is Dunning’s [9][10] eclectic paradigm. It postulates that the extent and pattern of international production is determined by the configuration of ownership or firm-specific advantages (such as proprietary technology, products, expertise and skills), locational advantages of host and home countries, the internationalization of these advantages across national boundaries to overcome market imperfections or failures, reduce transaction costs and maximize economic returns [3]. These so labelled OLI variables explain why internationalization (or expansion across national boundaries) occurs but do not explain the dynamic process of internationalization. The international development path, IDP [7][8] provides the eclectic paradigm with a dynamic dimension by relating the net outward investment of a country to its stage of economic development. At a low level of economic development (stage one), there is little inward or outward investments. Most developing countries are in stage 2 while the NIEs are at stage 3. At stage 4 of the IDP, net outward investment is positive with production being multinationalized. Most developed countries are at this stage. Research on multinationals from emerging countries (including Asian countries) has given general support to the IDP concept (e.g., [8][12][24]). According to Dunning, van Hoesel and Narula [13], the second wave of MNEs encompasses firms mainly from East Asian NIEs. The MNEs from these countries have improved and augmented ownership advantages (e.g., innovatory capabilities) and make more strategic seeking FDI (for technology and marketing) in advanced industrial countries via higher equity and control modes (e.g., through mergers and acquisitions). The authors argue that the second wave is consistent with the IDP explanation (stage 3). The IDP concept remains vague about the precise relationships between the underlying advantages (factors) and the pattern of inward and outward FDI or stage of IDP [43]. The macro nature of IDP studies has contributed to this knowledge gap. Does the IDP contribute to an understanding of the international expansion of firms from a fast developing country, like Malaysia?

The above concepts, while providing understanding and explanation of the internationalization of MNEs, do not provide a complete explanation of MNEs from Asian countries. The Asian MNEs do exhibit characteristics, motivations and internationalization paths that vary from those MNEs from developed countries. Mathews [29][30] postulates that emerging Asian firms can achieve accelerated internationalization via leverage of their contractual linkages with other foreign firms to acquire resources and learn new capabilities. He indicates that this can be an explanation to complement the OLI framework in explaining the rise of such latecomer firms which he dubs as ‘Dragon multinationals’. Mathews and Zander [31] also view the initial stages of rapid internationalization in terms of international entrepreneurial dynamics. Theories on internationalization tend to overlook the active role played by the state and neglect the institutional, contextual and socio-cultural perspectives in the internationalization of Asian firms ([48][52][26]). Asian internationalization tends to be organized through social and ethnic networks. Chinese culture and business practices with its own sets of values and beliefs underpin the way Chinese business and cross border operations are conducted ([49]). Personal relationships and networks (e.g., [17][26]) form the basis of the internationalization of Chinese and Asian firms. Hence the internationalization of Asian MNEs needs to be seen in its contextual embeddedness (both institutional and cultural). It is imperative to combine these contextual perspectives with the economic perspective normally used to explain the internationalization of MNEs from developing countries. Such differences are being recognized in the literature as reflected in Peng, Wang and Jiang [37] and Luo and Tung [27].

In recent years the phenomenal growth of overseas FDI from large emerging BRIC countries has prompted research into the motivation, behaviour and strategies of MNEs from such emerging countries. Luo and Tung [27] propose a springboard perspective to capture the special characteristics of these MNEs not adequately covered by the eclectic paradigm. These emerging markets MNEs try to overcome the disadvantages of being latecomers through aggressive acquisition of critical strategic assets and opportunities from advanced markets via rapid internationalization. Similar perspectives were provided by Mathews [29][30]. Buckley et al. [4] in their analysis of Chinese outward FDI also indicate that traditional theory can be refined to take account of their special characteristics such as capital market imperfections, special ownership advantages and institutional factors of Chinese outward FDI. While these are recent contributions to the study of MNEs from large emerging markets, there is limited empirical research examining MNEs from other emerging economies, particularly in Asia. Further research is required in order to have a fuller and complete picture of MNEs from emerging economies. This paper presents empirical data on a sample of case firms from Malaysia (a fast developing economy) using a longitudinal study spanning 1999 to 2010. Based on these preliminary findings, research propositions are suggested for more rigorous research investigation and testing.

**RESEARCH METHODOLOGY**

This study utilizes a longitudinal case study approach. The case study approach is used to collect comprehensive, contextual and holistic data (Yin, 1994; Eisenhardt, 1989; Siggelkow, 2007) from firms that internationalized their operations over time. This will provide data for more extensive subsequent research and testing of propositions. The data is primarily drawn from field interviews with the CEOs or top executives responsible for the international operations of the firms in their home countries. As our focus is on the internationalization and strategies of the parent firms, overseas subsidiaries were not interviewed. In addition, the difficulty of accessing these overseas subsidiaries and financial constraints limited the scope of the study to home countries. Multiple sources of information are
used to cross check and validate the information and data collected. In addition to interviews, annual reports, prospectus, presentation to security analysts and bankers, news releases and other publications were requested and collected from the firms visited. Data from other secondary sources, including published materials in business and professional periodicals, journals and internet web sites, were used to supplement the primary material. This use of data from various sources allows us to cross check and verify data and to ensure validity. Case notes were prepared, tabulated and analyzed for each case firm along the lines indicated by Miles and Huberman (1994) for each of the study time frame. Summary tables of the case firms are presented in the Appendix for discussion here. Five case studies are used in this paper to report on their internationalization over a period from 1999 to 2010. These firms were originally interviewed in 1999 ([40]) and again in 2010. Visits to these firms were also made in between these 2 periods. These firms are in the garment, electronics, consumer and diversified sectors. They requested anonymity and confidentiality as a condition of continued participation and are accordingly disguised in the paper. The reluctance of firms to participate in the research was encountered by the researcher and posed a common problem of research in Asian countries.

**FINDINGS ON INTERNATIONALIZATION**

**BACKGROUND OF CASE FIRMS**

Our case firms vary in size in terms of sales (2009 data) from MYR16.2 billion to MYR56.1 million with an average size of MYR3.6 billion (the exchange rate of MYR, Malaysian Ringgit is about MYR3.40 to the USD in 2009). The largest firm is a diversified firm (designated as DL), followed by one in consumer product (CP), electronics (ET), garment and property (GP) and another in electronics product (EI). While these firms are much smaller in size compared to MNEs from the developed countries, they are representative of MNEs from Malaysia ([38]). The attempt to internationalize started in the early 1970 for our case firm, DL, with a venture in Indonesia. However vigorous international activities for our firms started only in earnest in the 1990s. In fact, most of our case firms really began rapid internationalization in the mid-1990s. Hence most of our case firms are relatively late comers in internationalization. The Asian currency crisis (AFC) in 1997/98 stopped the frenzy of overseas expansion, with international expansion proceeding at a much more tampered and considered phase.

Case firm GP is in garment, retailing and property development. Most of its garments were exported, largely on an OEM basis. The search for low cost bases and quota was the main motivation for it to set up plants on a wholly owned basis in Sri Lanka in 1993 to supplement its factories in Malaysia. Expansion followed and four factories were set up in Sri Lanka by 2000. The firm also diversified into property development. After the expiry of the multi-fibre agreement (MFA) in 2004, demand for its garments fell and three factories in Sri Lanka were closed by 2006. By 2009 the remaining overseas factory and all Malaysian factories, except for one, ceased operations as the firm was no longer competitive in the global garment market. During the down turn in its garment business, the firm diversified aggressively into property development and retailing areas. In 2009, the garment business has fallen to only about slightly more than 10% of its turnover. In the electronics sector, the two case firms have different international experience. Firm EI was an entrepreneurial venture set up to produce and adapt electronics products (e.g., display and multimedia systems) to local and overseas markets. The search for technology was a dominant motive for it to seek partners in China and to acquire an Australian firm for its power technology in 1995. However, the Australian venture was disposed off in 1997 and the Chinese operation thereafter, particularly after suffering severe decline during the 1997 Asian financial crisis. With the emergence of Vietnam as an attractive market, the firm set up two wholly owned operations there in late 2006 and 2007. So its progress has been chequered. The other electronics firm, ET, is a disk drive and electronic components manufacturer, supplying to local customers on an OEM basis. With its precision engineering expertise gained through decades of production experience, it grew and internationalized with the global electronics industry. Its internationalization was largely to follow its major customers for marketing opportunities and to use lower cost bases. A 60% joint venture (JV) was set up in China in 1996. This was followed by two wholly owned plants in the Philippines in 1997 and 1999. A factory was set up in Thailand in 1998, followed by another in 2006. In 2003, a Singaporean firm was acquired with 60% ownership. The ownership level was subsequently raised to 75% in 2006 and 100% in 2009. Firm ET was able to successfully weathered the recessions in late 1990s and the global financial crisis (GFC) in 2007, largely due to its prudent financial policy and resilient management.

Firm CP in the food and flour sector has extensive businesses in Malaysia. The expansion into overseas production was basically to seek lower cost bases and to diversify its markets. It set up a subsidiary (100%) in Myanmar in the mid-1990s to manufacture labour intensive packing bags. In 1998 a JV (52.5%) was started in Vietnam to manufacture flour. This JV was converted into a wholly owned subsidiary (WOS) in 2001 after the withdrawal of its two partners. As this firm was a member of a larger regional grouping, some of its businesses were rationalized and sold to other affiliates. A large asset in Malaysia was also disposed off. As a result there was a renewed push to grow via internationalization in the late 2000s. Another packing bag plant (30% JV) was set with a network partner in 2010 in Indonesia. In Thailand there were two JVs, one in flour and one in feed mill. In Malaysia the firm is vigorously pursuing vertical integration moves along its value chain.

Firm DL is the most diversified of the case firms, with interests in retailing, steel, motor vehicles, property and plantations, has grown via diversification and internationalization. While it had gone into Indonesia in 1972 to expand its metal works business, its main overseas focus is in China where it entered in 1993 and build up major businesses in motor vehicles and components, tyres, retailing, brewery, foods and

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property. It also had computer related operations in the U.S., Germany and Taiwan, but these have been rationalized since. As a result of its rapid expansion, particularly in China, and high gearing, it was severely impacted by the Asian financial crisis in 1997 and had to undergo an enforced group wide restructuring and rationalization scheme in the early 2000s. This involved capital restructuring, re-organization and a divestment plan of MYR4.3 billion worth of non-core assets. With some residual rationalization still in progress, the firm now intends to focus on retailing, steel and property. Its emphasis is on retailing in China (with 44 stores) and in Vietnam (6 stores), which it entered in 2005.

**DISCUSSION AND RESEARCH IMPLICATIONS**

The above findings indicate that our case firms tend to concentrate their overseas operations in the Asian area, particularly in South-east Asia and China. They have limited number of number of overseas production locations, usually in two to four countries. The diversified firm DL has active operations in 5 countries, including the U.S., Mexico, China, Vietnam and Indonesia. Electronics firm ET is in 4 Asian countries. At the start of this research in 1999, ET was in 3 countries, but has since expanded their operations in the Philippines and Thailand and acquired a new Singaporean subsidiary. The other electronics firm, EI, withdrew from their initial operations in China and Australia and is now in Vietnam and Singapore. Consumer products firm CP expanded their international operations from 2 countries in 1998 to 4 countries in 2010. Garment firm GP has ceased operations in Sri Lanka due to its lack of competitiveness in this industry following the termination of MFA and increase in labour cost and has initiated a JV in property development in Indonesia. The size of our case firms has a constraining effect on the geographical spread of their internationalization. With limited resources, these firms tend to extend their current products and technologies to nearby countries with similar economic and cultural environments. In addition, these countries provide locational advantages for our sample firms. The choice of proximate country in the initial stages of internationalization is consistent with the internationalization processes of the Uppsala School [20]. The combination of cultural proximity, the existence of locational advantages in the neighbouring countries and the attraction of the large China market influence the regional character of our case firms. In addition the spread of our case firms in the Asian region was facilitated by the existence of ethnic (Chinese) business networks that our case firms can draw upon. These networks allow firms to leverage their linkages to acquire market and other knowledge to become more competitive ([19][34]). All our case firms are Chinese controlled and have ethnic and dialect links in South-east Asia and China. For example, firms GP, CP and DL have extensive ethnic networks of related or affiliated businesses and suppliers in Asia. As such, our case firms were and remain as regional in scope and character over the 11 year period studied.

The extent of multinationalization is expected to be greater as a country moves to a higher stage along the investment development path. Our case firms had fewer overseas locations in terms of international spread than MNEs from advanced or newly industrialized countries. The case firms tended to concentrate in the Asian region. Two case firms had begun to move to the developed countries. This is also observed by van Hoesel [43] for his sample firms at stage 3 of the IDP in Asia. It is interesting to observe the early investment in Australia by our electronics firm EI to acquire technology, but this was subsequently divested after two years of trial, probably indicating the lack of international experience at this early stage of internationalization. Case firm DL had investments in the U.S and Europe, but now only the U.S. venture remains. The learning opportunity for more advanced technology did not work out for these 2 firms. It seems that the proposition of Mathews [29][30] and Luo & Tung [27] to seek strategic asset building capabilities for accelerated or springboard internationalization has not worked out for our case firms. Hence our case firms are clearly in stage 2 of the IDP. These firms have to augment their innovatory technological skill base to enhance their ownership advantages to advance further along the IDP. Further research into the lack of technology acquisition by our case firms, as well as other Malaysian firms, can be instructive to provide potential avenues for greater internationalization.

Our case study firms internationalized their operations in the 1990s. The exception is firm DL which started overseas production early in 1972 in Indonesia. Many Malaysian firms, including our case firms, buoyed by economic growth in the late 1980s and early 1990s went overseas aggressively with the active encouragement of the Malaysian government. In the 1990s, firm DL was particularly aggressive in expanding its operations in China in its core businesses and newer businesses such as brewing and foods. Garment firm GP started in Sri Lanka in 1993 and expanded to 4 factories there by the mid-1990s. Similarly, the other 3 case firms internationalize at around the same time. However the AFC in 1997/98 put a halt to the active overseas expansion as many Malaysian firms, including our case firms, have to rationalize and reorganize to overcome the adverse impact of the crisis and the subsequent recessions. Firm DL was severely affected and made losses for several years. It was forced to undertake a group wide restructuring and disposal of assets. The other case firms were not so severely affected. But international expansion was more constrained and measured. In the mid-2000s, garment firm GP was adversely affected by the end of preferential treatment accorded by the MFA and increasing labour cost. It had to close it 4 garment plants overseas. By 2010 its international operation is now confined to a JV in property development in Indonesia. The global financial crisis (GFC) in 2007/08 did not have a severe impact on our case firms. In fact, firm CP expanded operations in Thailand and Indonesia.

In general, our case firms were relative late comers to internationalization. The longitudinal progress of international expansion of our case firms is reflective of MNEs in Asia. Mathews [29][30] argues that late comer firms can be successful in globalization by learning and building technological capabilities quickly and successfully through leverage of their overseas linkages. Luo and Tung [27] see
this as the springboard effect. Gubbi et al. [16] provide some empirical evidence that firms can reap greater value creation through acquisition of strategic assets from firms in advanced countries. However our case firms do not seem to be doing this. Earlier attempts by firm EI and DL going to the advanced countries for technology acquisition have not proved to be fruitful. Their experience in these market and technology fields may have limited their absorptive capacity for learning and knowledge acquisition ([5]). However, all our case firms have enhanced their knowledge of doing business in their host country markets and performed well. Firm DL is particularly successful in the Chinese market which is reputed to be a difficult market to penetrate. What factors determine the success in one area of knowledge acquisition and not in another for our case firms and other Asian firms is an interesting research question that deserves further investigation and research.

The main motivations for the internationalization of our case firms were market expansion and the search for low cost inputs. This is also true of other Malaysian firms in general. The constraints of the domestic market encouraged Malaysian firms to seek overseas markets. Market expansion was a dominant motive cited by all our case firms. The search for low cost bases was particularly evident in the international expansion of firms GP, CP and ET. These 2 motivations for continued internationalization have not changed for our case firms over the time period studied. For firm GP, market expansion was the main motive for its recent moves to Indonesia and Thailand. This was particularly so as a consequence of the narrowing and rationalization of its business focus in food processing and retailing. Market motivation was the key to the move into Vietnam by firm EI in 2006, by firm DL in 2005 and by firm GP into property development in Indonesia. Similarly firm DL expanded its operation in China and ET in Singapore. Technology acquisition as a motive was only mentioned by firm EI and DL. Firm EI was in China to seek applied R&D collaborative arrangements and in Australia for power related technology. Firm DL’s operations in the U.S. and Germany were to tap technology for its computer based business. As mentioned previously, these ventures did not prove very fruitful. Firm EI ceased its overseas operations and DL exited Germany. Other than these attempts in the mid-1990s at technology acquisition, no specific technology based acquisitions were subsequently attempted by our case firms. This differs from the more progressive MNEs from the more developed Asian countries in stage 3 of the IDP that have augmented their technological and other capabilities suitable and required for global operation ([41][30][27]). Our case firms indicated that their emphasis was to learn how to operate successfully in the host country business environment and that their current technological enhancements were adequate. This apparent lack of foresight and long range planning in terms of technology acquisition and development of ownership advantages required for global competition is intriguing and presents opportunity for research. Is this applicable to other firms from Malaysia and other Asian countries? This is a fertile area for study.

The sources of competitive advantage of our case firms are based on cost competencies and adaptation to host country markets. The cost advantages are generally based on more labour intensive processes, flexible production and appropriate technology. For example, the competitive advantage of garment firm GP is based on a cost and OEM orientation and a reputation for quality and reliability. Its production in Malaysia and Sri Lanka are mainly for export to European and North American markets. To reduce dependence on textiles, it has diversified into retailing, trading and property development. Our electronics firm, EI, relied on its own technical expertise and its ability to design and tailor advance electronics displays to host market requirements at competitive prices. This company is conscious of its need for technology and acquired an Australian firm for its technology (but subsequently divested) and used its China venture and networks to tap technology tailored to the Chinese market. It has a conservative approach to internationalization and expands when its capacity can sustain them. In the consumer product firm in our sample, location-based cost advantages are important. Firm CP has a packaging plant (to make polypropylene bags) in Myanmar, and has gone into joint venture with Australian (17 1/2% equity) and Vietnamese interest (30%) for flour production in Vietnam. These investments are cost driven, though the local market for flour and noodles is also a key determinant for investment in Vietnam. In addition it draws its strength as a member of a Chinese based business group and network in South-east Asia and other parts of Asia. Cross investments and transfers of local expertise takes place within this business network of members. Firm DL, a large conglomerate with businesses in steel, plantations, property, motor vehicles and components, tires, food and beverages, retailing and financial services, has grown via diversification and internationalization. While it has gone to other countries, its main focus is in China, where it entered in 1993 and built up major businesses in motor vehicles and components, tires, retailing, brewery and properties. It had computer related operations in the U.S., Germany and Taiwan, but these have since been rationalized. The competitive advantage of firm DL in China is its intimate market knowledge and extensive network built up over years of development in China, particularly by its CEO. This firm stressed the importance of patience, perseverance and a very long term view in developing the China market. Considerable care was also taken in selecting the right partners. Most of its successful businesses in China were also built on competencies developed in the domestic market such as retailing, motor vehicles and components. It also did well initially in the brewery business in which it had no domestic competencies or business, but it brought in required expertise for the China operations. However the brewery business was later disposed off. From a learning perspective, firm DI was successful in exploiting and leveraging its existing knowledge and capabilities, but not so successful in exploring new technology knowledge and businesses ([1]).

Over the period of this longitudinal study, the competitive advantage of our case firms has varied. The cost and preferential access based competitive advantage of garment
firm GP have vanished and it had to cease overseas production and curtail domestic capacity. Now it has diversified to focus on property development and retailing. Its only international activity now is a JV with its network partner in Indonesia. Firm EI acquisition of technological know how did not pan out and now it relies on its own expertise to adapt technology to local markets. It has reverted back to rely on the exploitation of its existing capabilities, rather than the exploration of new technological innovations from advanced markets. Firm ET worked closely with its global electronics customers to enhance and leverage its precision engineering capabilities. This, coupled with its own strong management capabilities, allows it to expand its international operations. Consumer product firm firm CP utilized its extensive ethnic networks to set up new and recent JVs in Indonesia and Thailand to capitalize its experience and skills in food processing. Firm DL which was severely affected by the recessions in the late 1990s and early 2000s rationalized its overseas businesses to focus on its core strengths of retailing and intimate knowledge of and networks in the China market. While cost competencies are still important, our case firms have expanded and utilize other sources of competencies to compete and grow.

In the early stages of internationalization, most of our case firms exhibited a preference for JVs. This is similar to other Malaysian and Asian MNEs. For example, DL made extensive use of JVs in China. Over the years, its use of WOS increases, even in China, in order to exert greater control of its overseas operations. In addition ownership restrictions in some Asian countries, including China, have been liberalized over the last 10 years. Firm ET started with a JV in 1996 in China, but subsequently set up WOS in the Philippines and Thailand. By 2010, all its operations in the Philippines, Thailand, and Singapore are wholly owned, while the equity control of its Chinese JV has increased to 90% in 2003. So there is a clear trend towards greater control by firm ET over the time period under study. The experience of firm EI was an initial JV in China followed by an acquisition in Australia. After their disposal, it entered Vietnam on a wholly owned basis. The changes in greater incremental commitment of the above cases reflect the prescription of the Uppsal model. Garment firm GP is the only case firm using WOS in its initial and subsequent garment ventures in Sri Lanka. However these were all closed down after the end of the MFA in the mid-2000s. Its later overseas venture is a JV in Indonesia. Consumer product firm CP used both WOS and JV in its initial years. The JV in Vietnam was converted into a WOS after the withdrawal of its 2 partners. In recent years, its internationalization expansion in Thailand and Indonesia involves JVs with network partners of long standing. This trend towards greater use of strategic partnerships is different from the other case firms. This can be explained by its desire to grow quickly by leveraging its production expertise with the market knowledge of its partners. This inclusion of the utilization of network partners, even at a later stage of internationalization, is reflected in recent addition of network effects to the Uppsal model ([21]). Hence, the longitudinal development of our case firms in terms of equity control varied.

In terms of the management of the overseas subsidiaries or JVs, there is generally central or HQ control and this has not varied over the period of the longitudinal study. In both electronics case firms the management of overseas operations were by top management in the parent companies. In firm ET, control was progressively increased as the equity stakes in the JVs were increased to 90% in the case of China in 2003 and 100% in the case of Singapore in 2009. Key decisions were made by the CEO and COO out of HQ. After the withdrawal from China and Australia, firm EI centralized the management of its Vietnam operations. In CP, our consumer product case firm, the management of the subsidiaries varied by country location. In its wholly-owned operations, including a processing plant in Vietnam, key management and decision making were made at head office in Malaysia. Top Malaysian managers ran this business, while the production manager and workers were Vietnamese. In its Indonesian joint venture, which was majority owned, the general manager and financial officer were Malaysians, while the local partner headed marketing in which he had expertise. Production personnel were local Indonesians. However, technical expertise was provided by technicians from Malaysia. The labour intensive operation in Myanmar was run out of head office, with local employees doing the production work. In the recent JVs in Indonesia and Thailand, management was shared with its partners utilizing the expertise of the respective parties. In the diversified firm, DL, the management and organization of operations, both in Malaysia and overseas, was by business divisions. The most substantial overseas operations were in the retail business, where the firm operated a large chain of departmental stores, particularly in China, and in motor and tyre sectors, where it had vehicle assembly plants and tyre manufacturing in China. The firm had two China offices in Beijing and in Shanghai where the China managers for these divisions were stationed. The management and control of the overseas subsidiaries in firm DL was tight, with limited decision making authority being delegated. This was due to the Executive Chairman (CEO) of the DL group being a very hands-on CEO. In fact, it was the CEO who initiated and spent considerable time developing and establishing the China businesses and networks. The CEO and his senior executives travelled regularly to China and conducted at least two formal business reviews every year. This was in addition to the monthly operations reviews which are supported by detailed monthly reports from the subsidiaries. With constant interaction between head office and the overseas locations, coupled with formal business and financial reports, the Kuala Lumpur head office maintained a very close supervision of all of its international operations. This central control has not changed over the 1999-2010 period studied.

As can be seen from the case studies, management control of overseas operations tends to be increase over time. This seems to be quite different from recent calls for greater decentralization and autonomy in the management of subsidiaries in MNEs ([2][36][28]). Such differences in our case firms and in the Malaysian context merit further research.
CONCLUSION

This preliminary study provides new empirical longitudinal research data on the internationalization strategies of emerging Malaysian firms over a period of 11 years. Over the period studied, some aspects of strategies utilized by our case firms have changed while others have not. Our case firms, with the exception of firm DL, are late comers to internationalization and have become regional MNEs. This seems consistent with the Uppsala model. Over the time span studied, the motivations for international activities have remained largely market and cost driven. Two of our case firms indicated technology seeking motive but this motivation was diminished by the lack of success. So in terms of learning, there is limited technology acquisition and less reliance on acquisition of strategic asset-seeking advantages from the advanced countries, as advocated by recent studies [27],[30] that such knowledge acquisition can leverage accelerated internationalization for firms from developing economies. But our case firms are acquiring knowledge and skills for operating in the host market environments in China and other parts of Asia. This learning and knowledge of the host country markets is facilitated by the existence and use of the ethnic networks and relationships cultivated by our case firms in the region. Hence the competitive advantages of our case firms are based on cost-based capabilities and other location-based advantages, brought together by an extensive web of networks.

In terms of mode of internationalization, our case firms utilized both joint ventures and WOS over the time period studied. The increase in use of the WOS mode as internationalization progresses is evident in most of our case firms. The increasing use of equity ownership over the time period studied is accompanied by the high management control of subsidiaries from the HQ and reflects a trend towards greater internalization of advantages within our case firms. This is in accord with both the Uppsala and eclectic approaches.

This study reveals some interesting and different aspects on internationalization of our case firms over the 1999-2010 years under study. How will our case firms evolve and will they follow conventional prescriptions of internationalization and growth? Knowledge on this will depend on further research undertaken in areas as indicated in the discussion section of the paper. The above findings are preliminary in nature and the key limitations of this study should to be noted. The empirical base is small, utilizing a study of five case firms. The use of a case study method here has its shortcomings, such as the limited sample size and the danger of generalizing the findings beyond the cases. Hence the findings are exploratory in nature and form the basis for our research propositions suggested for further empirical study using large scale samples. Research into these areas will provide a better and more comprehensive understanding of Asian MNEs, as well as MNEs in general.

REFERENCES


IN SEARCH OF FINANCIAL PERFORMANCE SUPERIORITY VIA PRODUCT AND CUSTOMER PERFORMANCE OUTCOMES: THE ROLE OF COMPLEMENTARY RESOURCE-CAPABILITY COMBINATION WITHIN AND BETWEEN INNOVATION AND MARKETING AREAS

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ABSTRACT

The primary focus of this paper is to specifically examine the roles of complementary within innovation resources-capability and marketing resources-capability combinations in achieving financial performance through product and customer performance outcomes. Using data from 171 small and medium sized manufacturing firms, the results suggest that complementary innovation resources-capability combination, complementary marketing resources-capability combination and their interaction are positively related to financial performance through product and customer performance outcomes. Interestingly, the results indicate that innovation resources-capability complementarity contributes more to financial performance via product performance than via customer performance. Likewise, marketing resources-capability complementarity contributes more to financial performance via customer performance than via product performance.

Keywords: complementary resource-capability combination, innovation and marketing, product performance, customer performance, financial performance.

INTRODUCTION

The resource-based view (RBV) articulates a view that a firm’s resources and capabilities underpin its ability to achieve superior performance outcomes [1-5]. While this point is valid and has much to offer, some scholars argue that much of the literature within RBV has emphasized performance at a macro-level in the form of firm profit and the like to the neglect of performance at a micro-level in areas such as customer performance and product performance [1,6,7]. Ray et al. [8] argue that while investigating the effect of a firm’s resources and capabilities on financial performance may be of intrinsic interest to both scholars and managers, it may lead to misleading conclusion. Further Coff [9] argues that once we do not observe a firm experiencing high levels of performance does not mean that profits are not being generated. For example, firms that invest significant resources in developing new products may enjoy achieving superior product performance when the financial performance of these firms may not be high. Likewise, firms that invest significant resources in marketing their products and serving customers will yield superior customer performance when the financial performance of these firms may not be immediately seen.


This issue is important since managers are being pressured and required to increasingly customize their products to meet customers’ demands [12] and to serve customers better [11]. Despite the theoretical and practical importance of these issues revolving around macro-level and micro-level performance, surprisingly, little attention has been devoted to exploring performance at a micro-level covering product and customer performance as mechanisms through which firms realize their investments in resources and capabilities to achieve superior financial performance (macro-level).

While the work of Penrose [13] has been regarded as the founding mother of the RBV, Barney’s [2] discussion of RBV is the first to formalize the RBV literature into a more cohesive theoretical framework where he proffered the view that a firm’s heterogeneous resources [that meet the specific criterion of being valuable, rare, inimitable and non-substitutable (VRIN)] help firms achieve competitive advantage that eventually lead to superior financial performance. However, Barney’s expression [2] of RBV has been strongly criticized over time, especially in regard to its rather static nature [14]. Further, some scholars have also argued that a firm may achieve superior financial performance, not because of its resources, but rather because it has distinctive capabilities that can be applied to leverage and deploy its resources [5,15]. Newbert [16] has later argued that resources and capabilities are effective only when they are deployed in combination. Further, the advancement on the notion of asset orchestration by Sirmon and Hitt [17] implies that superior financial performance is achieved not only when resources and capabilities are deployed in combination but also when resources and the processes by which these resources are deployed have a high degree of “fit”. Despite the theoretical and practical importance of resource-capability combination raised by Newbert [16] and resource-capability complementarity raised by Sirmon and Hitt [17], surprisingly, much of the attention to firm financial performance within RBV has on either resources or capabilities separately.

Further, while studies by Newbert [16] and Sirmon and Hitt [17] attempt to enrich our understanding on the role of complementary resource-capability combinations in firm financial performance, scholars have not yet fully identified which complementary resource-capability combinations are critical and how combinations achieve superior financial performance. As such, the key for firms is to identify the complementary resource-capability combinations that will lead to superior financial performance.

In addition, whether complementary resources-capability combinations within different areas have different effects on
different types of performance has not been investigated. This issue is critical since firms may possess superiority in some resources and capabilities and inferiority in others and more importantly firms that possess specific resources and capabilities may achieve more in specific marketplace performance outcomes [9] that will eventually lead to superior financial performance.

Moreover, the limited attention given to the interplay between resources and capabilities (within specific area) in driving firm financial performance has seen scholars bypass an important issue in indentifying the complementary resource-capability combinations between areas that have the potential to be synergised to achieve superior financial performance. This study argues that the neglect on this important issue has left unexplored how firms may achieve beneficial outcomes through and prevent imitation through complementarity in resource-capability combinations both within and between specific areas within the firm.

The purpose of this study is to advance our understanding of the role of complementary resource-capability combinations within and between specific areas within firms in achieving superior performance at a micro-level (which we might view as first-order performance) in areas such as customer or product performance outcomes, as well macro-level (which we might view as second-order performance) financial performance. This study contributes to the literature in three primary ways. First, extending Drucker’s [18] view that marketing and innovation are the keys for firm success and others who have put marketing [19,20] and innovation [21] at the forefront as drivers for achieving superior financial performance, this study identifies that complementary marketing resources-capability combination (R-C marketing) and complementary innovation resources-capability combination (R-C innovation) are the key drivers for firms achieving superior financial performance with respect to product and customer performance. Second, extending the notion of resources-capability combination proposed by Newbert [16] and Sirmon and Hitt [17], this study identifies that superior complementary resource-capability combination within different areas contribute differently to firm specific performance such as customer and product performance that will eventually lead to superior financial performance. Third, extending the work of Ray et al. [8], this study identifies how R-C marketing and R-C innovation and their interaction achieve superior financial performance (which we identify as macro-level performance) through the firms’ customer and product performance (which we identify as micro-level performance).

**THEORY AND HYPOTHESES**

RBV addresses the importance of resources that are valuable, rare, imitable, and non-substitutable in driving firm superior performance [2,3]. While this argument has been widely accepted among scholars, it has been argued that resources are of no real value in isolation [5,15]. It is in fact how those resources are deployed through firm idiosyncratic capabilities in ways that match the firm’s market environment that better explain firm performance differentials [4,5,15]. While these two approaches have dominated the debate in explaining firm performance differentials, the RBV’s core logic has been neglected. The early work within RBV by Winter [22] is; however, premised on the view that while resources are no doubt critical to firm’s superiority in the marketplace, they are by themselves insufficient. They argue that with resources in hand, firms need to also possess capability to deploy those resources to achieve superior performance outcomes. In a similar vein, Connor [23] suggests that firms are seen as a pool of resources and capabilities implying that firms need to possess both resources and capabilities simultaneously to achieve superior performance. Consistent with this view, Newbert [16] has recently argued that resources and capabilities may have effect on firm performances only when they are deployed in combinations. It is because resources are statics [14] and have no value in isolation [24]. Capabilities, in a similar vein, do not produce any value without the presence of resources to be deployed [25]. Sirmon and Hitt [20] have later argued that the ‘fit’ between resource investments and their means of deployment is important for firm performance. Derived from this argument, one may argue that to achieve superior performance, firms may not only deploy resources and capabilities in combination but that resources and capabilities must complement one another. In this context, the key for firms is to identify and develop specific sets of complementary resources-capability combinations that will yield competitive advantage and eventually lead to superior firm performance.

Due to globalization and increases in competition, it is undeniable that every firm need to engage in developing superior products and introducing products to the market through cutting-edge marketing strategies to be successful in the marketplace. This assumption is also theoretically supported by the conventional wisdom proposed by Drucker [18] that firms must be good at both innovation and marketing to be successful. Further, there is also a strong evidence within the literature where scholars have put marketing [19,20] and innovation [21,22] at the forefront as drivers for firms to achieve superior performance.

Contingency theory emphasizes on the performance effects of ‘fit’ which has been defined as the matching of two or more organizational factors of concern [26]. Scholars have adopted the contingency perspectives and have examined many organizational factors including strategy/structure [27], strategy/environment [28] strategy/governance [29], resource investment decision and resource deployment decision [17], among others. Overall, these streams of research, spanning organization theory and strategic management, suggest that better fit yields higher performance. Despite the advances in our understanding of these particular contingencies, little is known about the outcomes of the relationship between resources and capabilities.

Building on this premise, this study proposes that innovation resources and innovation capability are complementary in ways that they are both at superior level and their interaction enhances the effectiveness and efficiency of the firms as do marketing resources and marketing capability. This study examines innovation resources (e.g., patents) as key resources and marketing resources as key capabilities.
innovation-based asset, marketing resources (e.g., firm reputation, product reputation) as key marketing-based assets, innovation capability as a key innovation-relating deployment mechanism and marketing capability as a key marketing-relating deploying mechanism. Specifically, this study adopts the position that complementary resource-capability combination within specific areas (such as marketing or innovation) may not contribute to firm performance in isolation. This study further contends that the performance impact of complementary resource-capability combinations rest on the interaction effect between specific areas that are complementary with one another (such as marketing and innovation). Based on this theoretical platform, this study develops the theoretical model with testable hypotheses as shown in Figure 1.

**FIGURE 1: Framework of the Study**

The RBV has been adopted by scholars in various fields to explain differential firm performance. However, the issue of resources, capabilities and market context specificity has received little attention to-date except for [1,6,7]. Amit and Schoemaker [1] argue that resources are valuable in the context of a specific market, and Peteraf and Bergen [7] have linked the value of a resource and its application to the satisfaction of customer needs. Further, Collis and Montgomery [6] suggest that if a resource is valuable, it must contribute to the creation of something customers need. Following these theoretical contentions, customer and product performance are seen as a direct outcome in the context the firms’ ability to develop new products and deliver them to the customers, attract and retain customers, satisfy customer and increase sales to customers [1,7,8] that will eventually lead to superior financial performance.

It has been argued that innovation capability [21] and marketing capability [19,20] are crucial in achieving superior firm performance by developing new products and getting the products to the market successfully. The connection between innovation and marketing capabilities and superiority in the marketplace becomes apparent when one considers the point that markets are increasingly characterized by shorter product life cycles. This indicates more dramatic changes in customer’s preferences as customers tend to seek newer products and as such the firms’ ability to renew market offering and deliverer those offering to customers has become significant [30]. Nonetheless, it must be noted that to develop their products, firms may need complementary innovation resources such as machinery, technology, license, patents and the like to facilitate the manufacturing process. Innovation capability alone will not produce any superior products without the availability of innovation resources to be deployed [25]. Importantly, innovation capability enables firms to create new product offerings by leveraging innovation resources (such as patent, trademark and license) which make it extremely hard for rivals to imitate [31]. In a similar vein, innovation resources such as technology, patents, trademarks and licenses are insufficient by themselves to produce products without the existence of innovation capability to leverage and deploy them [32]. As such, firms possessing high level of R-C innovation are more likely to achieve superior product and customer performance that eventually leads to superior financial performance. Therefore,

**H1:** The relationship between complementary innovation resources-capability combination and financial performance is mediated by (a) product performance and (b) customer performance.

Similarly, to market and deliver products successfully to the marketplace, firms may need complementarity in marketing resources and capability. They need resources such as product reputation, company reputation and customer service reputation to facilitate the marketing process that results in product and customer related performance outcomes. Marketing capability alone is unlikely to bring the products to the market successfully. It is the reputation of the firm’s products, the firm itself, and its customer service which act as the drivers of customer’s choice [33]. In a similar vein, marketing resources such as product and company firm will not produce any value without the existence of marketing capability to leverage and deploy them [32]. As such, firms possessing high level of R-C marketing are more likely to achieve superior customer and product performance that eventually leads to superior financial performance. Therefore,

**H2:** The relationship between marketing resources-capability combination and financial performance is mediated by (a) customer performance and (b) product performance.

This study further argues that the achievement of superior financial performance via customer and product performance may be through the interaction effect of specific complementary resource-capability combinations within firms such as marketing resources-capability combination and innovation resources-capability combination that offer greater benefits than they offer in isolated form. Within this stream of research, there have been only a few studies focusing on the role of complementary capabilities in gaining marketplace advantage [34-36]. These studies deal with the complementary effects of marketing capability and R&D [34], and marketing capability and technology [35,36] to the neglect of the significant benefits and potential complementarity between marketing capability and innovation capability [22]. Extending this line of research, this study argues that the presence of both R-C innovation and R-C marketing is critical for firms to achieve superior financial performance via product and customer performance.

This study adopts this position because firms that pursue specific market opportunities, but are not innovative, are less likely to achieve or be able to maintain superior performance over the long run [37]. Similarly, innovation is itself not necessarily the sole driver in achieving superior performance because firms can leverage their innovation, develop offerings and or enter new markets, serve markets better or provide greater value than competitors if they possess strong marketing [38,39]. Therefore, firms that possess and deploy one resource-capability combination, but lack the other are at a disadvantage to those who possess and deploy both. As such firms possessing high level of the interaction effect between R-C innovation and R-C marketing are more likely to achieve superior customer and product performance that eventually leads to superior financial performance. Therefore,

H3: The relationship between the interaction between complementary innovation resources-capability combination and complementary marketing resources-capability combination and financial performance is mediated by (a) product performance and (b) customer performance.

Contingency theory also proposes that market and/or firm level influences may exist that make one or the other more important [40]. In line with this view of contingency theory, some scholars argue that different resources and capabilities (complementary resource-capability combination in this study) may produce different effects on different types of performance [8]. They further argue that specific resources and capabilities may be perceived as more important in achieving specific firm performance than others. Distinctive marketing should enable a firm to outperform its competitors by giving it the resources and ability to identify and serve the marketplace more effectively [41], yielding greater customer performance. Marketing is argued to enable firms to add value to their products and services to meet competitive demands [41] and plays a greater role in linking with serving customers and less of a role in actual product performance. This study extends previous research by arguing that firms that possess distinctive marketing are more likely to achieve superior performance in attracting customers, keeping them, satisfying them, and increasing sales to them which is at the heart of customer performance. This is similar to the point raised by Speed and Smith [42] that marketing offers a mechanism to improve competitiveness in the marketplace. The contention is raised here that marketing is a significant driver of a firm’s competitiveness and thus firms that possess distinctive marketing will have greater customer performance. Given that marketing contributes significantly to achieving customer performance, we contend that innovation contributes less to achieving customer performance. This does not imply that innovation contributes nothing. Innovation performs a vital role in delivering to the firm the products sought after in the market. It is through innovation that firms transform customer needs into quality products that can be leveraged to earn revenue.

An examination of the extant literature reveals that innovation is often tied more strongly into product performance than customer performance. Innovation is often tied to issues such as number of innovations, timeliness in developing products and newness of products developed [21]. However, the current body of work in these areas provides the basis for examining the relationship between innovation and customer performance as well as product performance. Innovation often creates leaps in market offerings, where customers seek out innovative products [43]. Indeed, innovation helps firms develop leading edge positions based on their breakthroughs, the timeliness of product developed and market entry and the newness are all driven by a firm’s innovation. In these areas marketing play a lesser role as the firm’s complementary innovation resources-capability combination is strongly geared toward product performance than complementary marketing resources-capability combination is. Therefore,

H4a: Product performance has a stronger meditational role on complementary innovation resources-capability combination – financial performance relationship than customer performance.

H4b: Customer performance has a stronger meditational role on complementary marketing resources-capability combination – financial performance relationship than product performance.

METHOD

The respondents for this study are Cambodian SMEs selected from provinces where the majority of manufacturing SME firms located [44]. Selected respondents were sorted alphabetically and by provinces from the list of all SME manufacturing firms obtained from the Ministry of Industry, Mining, and Energy of Cambodia. After the first initial contact, 350 firms agree to participate in the study. The most senior manager within each firm were the specific respondents chosen for this study as they are in a good position to respond to measures pertaining to capabilities and firm performance and that managerial perception is appropriate and yields reliable information [16,19,45]. Expert judgement and pre-test were conducted to enhance the clarity and readability of all items in the survey. One professional translator translated the original questionnaire in English to Khmer and then a second professional translator translated back from Khmer to English. Any differences were reconciled [46].

To ensure the integrity and reliability of the responses obtained, in line with Vorhies et al’s [20] approach, this study developed two specific questions to assess respondents’ knowledge and confidence. The respondents were firstly asked to identify their knowledge about their firms’ business operations, business processes, performance and business environment (at the beginning of the survey). They, then, were asked to rate their confident level in possessing necessary knowledge to complete the questionnaire (at the end of the survey) using 7-point Likert scale. Any respondents who answered below 5 to any of the two questions were dropped.

This study adopted drop-and-collect technique which is deemed suitable in developing countries [45] where issue with mail surveys and unreliable postal system [47]. This technique
Innovation Resources were measured via the 5-item scale adopted from [51]. Respondents were asked to rate the extent their firms possess innovation resources namely innovation resources (equipment and machinery), license, trademark, patent and financial resources (allocated for innovation-related activities) benchmarking to the industry average. A seven-point scale anchored by 1 ‘well below industry average’ and 7 ‘well above industry average’ was used in the current study. Marketing resources were measured via the 4-item scale adopted from [51]. Respondents were asked to rate the extent their firms possess marketing resources namely company reputation, product reputation, customer service reputation and financial resources (allocated for marketing-related activities) benchmarking to the industry average. A seven-point scale anchored by 1 ‘well below industry average’ and 7 ‘well above industry average’ was used in the current study. Innovation Capability was measured via the 5-item scale. This scale was built on the works of [52,53]. The innovation capability construct captures the firm’s ability to undertake specific routines and business processes to exploit the most-up-to-date technology available, developing new products, extending the firm’s product range, improving existing product quality and improving product flexibility. A seven-point scale with anchors of 1 ‘not at all’ and 7 ‘extensively’ was used. Marketing Capability was measured via the 9-item scale adopted from [19]. The measure captures the firm’s ability to utilize their marketing tools (routines and processes) they have in place to price, launch, distribute, and sell the products as well as developing and executing advertising and promotion, analyzing market information, managing sales, developing creative marketing strategies and translating marketing strategies into actions better than competitors. A seven-point scale with 1 ‘much worse than competitors’ and 7 ‘much better than competitors’ anchors was used. The use of different scale anchors when measuring firm capabilities has been adopted in previous research [19,41,54] and in this study the measures were based as close as possible on the historical approach to the specific construct’s measurement. Product Performance was measured via the 2-item scale. This scale was based on the work of [21,53]. Items that capture aspects of introducing new products and the number of successful new products were adopted. In this context new products can be either completely new products or new product adaptations. A seven-point scale anchored by 1 ‘much worse than competitors’, many less than competitors, much slower than competitors’ and 7 ‘much better than competitors, many more than competitors, much faster than competitors’. Customer Performance was measured via the 2-item scale. This scale was built on the work of [19,20]. The respondents were asked to identify a particular new product or a product adaptation and rate the level of satisfying and delivering value to customers for that particular product on a seven-point scale anchored by 1 ‘much worse than major competitors’ and 7 ‘much better than major competitors’. Financial Performance was measured via the 2-item scale. This scale was built on the work of [19,20]. The respondents were asked to rate the level of profit and return on investment for the new product or a product adaptation they identified in the customer performance setting on a seven-point scale anchored by 1 ‘much worse than major competitors’ and 7 ‘much better than major competitors’. This study controlled firm size, firm age, industry type, market uncertainty and technology uncertainty in testing our model. This study measured firm size and firm age with the logarithm of the number of employees to prevent. This study (dummy) coded firms based on the industry type they represent. Technology uncertainty was measured via 4-item scale while market uncertainty was measured via 6-item scale adopted from Jaworski and Kohli [55]. A seven-point scale anchored by 1 ‘strongly disagree’ and 7 ‘strongly agree’ was used in the current study.

DATA ANALYSIS AND RESULTS

Non-response bias was examined by comparing firms who had completed and returned the questionnaire (171) with those who had not (179) [56]. There was no significant difference in terms of sales and firm size (number of employees obtained from MIME) among the two groups, showing that the non-response was not a serious threat for the current study. We took another approach in comparing the average values found by the questionnaire of the first 10% of respondents with those of the last 10% using t-test [21]. There was no statistical difference from the result of the t-test between the two groups in term of the means for items, showing again that the non-response bias was not a serious concern in the current study.

Adopting a two-step analytical procedure similar to Hair et al. [57] and Hulland [58] the psychometric property of the measurement model and purified measured were first assessed and validated and then the structural model was assessed. The factor loadings for all items were well above the benchmarks while the average variance extracted (AVE) for all constructs exceed the recommended level of .50, thus, providing evidence for convergent validity [59]. The composite reliability for each of the constructs is well above the benchmarked level of .70, thus indicating that the measures were reliable [60]. Table 1 summarizes the results of factor loadings, AVE and the composite reliability test. Fornell and Larcker [61] suggest that that discriminant validity is evident if the square root of the AVE is greater than all corresponding correlations while O’Cass and Ngo [62] suggest that satisfactory discriminant validity among constructs is obtained when the correlation between two composite constructs (the off-diagonal entries) are not higher than their respective reliability estimates. As shown in Table 2, the square roots of the AVE values are consistently greater than the off-diagonal correlations and at the same time no individual correlations were higher than their respective reliabilities, thus indicating satisfactory discriminant validity of all constructs. Further, because the variance inflation factor (VIF) for all constructs range between 2.16 and 4.86, well below the VIF of 6 that Hair et al. [57] suggest is indicative of
harmful collinearity, it is assumed that all the correlations will not confound the results of any subsequent statistic tests [16]. On the basis of our reliability, convergent, and discriminant validity tests, we concluded that our measurement model satisfied psychometric property requirements.

**TABLE 1: Measurement Model**

<table>
<thead>
<tr>
<th>Construct</th>
<th>Items</th>
<th>Loading</th>
<th>t-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marketing Capability (CR = 0.96, AVE = 0.79)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(7-point scale 1 = “much worse than competitors” and 7 = “much better than competitors”)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Our firms’ marketing activities, compared to our major competitors, in terms of</td>
<td></td>
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<tr>
<td>MC1: Doing an effective job of pricing products has been</td>
<td>.86</td>
<td>51.94</td>
<td></td>
</tr>
<tr>
<td>MC2: Test marketing of new products has been</td>
<td>.89</td>
<td>72.68</td>
<td></td>
</tr>
<tr>
<td>MC3: Launching new products has been</td>
<td>.89</td>
<td>84.34</td>
<td></td>
</tr>
<tr>
<td>MC4: Attracting and retaining the best distributors have been</td>
<td>.89</td>
<td>89.55</td>
<td></td>
</tr>
<tr>
<td>MC5: Developing and executing advertising &amp; promotion programs has been</td>
<td>.88</td>
<td>71.21</td>
<td></td>
</tr>
<tr>
<td>MC6: Analysing market information has been</td>
<td>.89</td>
<td>76.39</td>
<td></td>
</tr>
<tr>
<td>MC7: Sales management has been</td>
<td>.90</td>
<td>89.03</td>
<td></td>
</tr>
<tr>
<td>MC8: Developing creative marketing strategies has been</td>
<td>.88</td>
<td>54.14</td>
<td></td>
</tr>
<tr>
<td>MC9: Translating marketing strategies into action has been</td>
<td>.88</td>
<td>61.57</td>
<td></td>
</tr>
<tr>
<td>Innovation Capability (CR = 0.89, AVE = 0.70)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(7-point scale 1 = “not at all” and 7 = “extensively”)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within this firm we have activities, routines, business processes and behaviours for</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IC1: Exploiting the most-up-to-date technology available</td>
<td>.82</td>
<td>31.75</td>
<td></td>
</tr>
<tr>
<td>IC2: Developing new products</td>
<td>.86</td>
<td>46.51</td>
<td></td>
</tr>
<tr>
<td>IC3: Extending the firm’s product range</td>
<td>.86</td>
<td>40.77</td>
<td></td>
</tr>
<tr>
<td>IC4: Improving existing product quality</td>
<td>.82</td>
<td>33.03</td>
<td></td>
</tr>
<tr>
<td>IC5: Improving production flexibility</td>
<td>.83</td>
<td>33.09</td>
<td></td>
</tr>
<tr>
<td>Marketing Resources (CR = 0.91, AVE = 0.79)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(7-point scale 1 = “well below industry average” and 7 = “well above industry average”)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Think about the competitive environment you operate in and indicate the extent to which you possess the following resources at a superior level to the industry average</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MarR1: Company reputation</td>
<td>.91</td>
<td>68.51</td>
<td></td>
</tr>
<tr>
<td>MarR2: Customer service reputation</td>
<td>.92</td>
<td>116.07</td>
<td></td>
</tr>
<tr>
<td>MarR3: Product reputation</td>
<td>.92</td>
<td>102.83</td>
<td></td>
</tr>
<tr>
<td>MarR4: Financial resources (allocated for marketing activities)</td>
<td>.78</td>
<td>25.48</td>
<td></td>
</tr>
<tr>
<td>Innovation Resources (CR = 0.92, AVE = 0.75)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>(7-point scale 1 = “well below industry average” and 7 = “well above industry average”)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Think about the competitive environment you operate in and indicate the extent to which you possess the following resources at a superior level to the industry average</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ImR1: Technological Resources (Machinery and equipment)</td>
<td>.84</td>
<td>42.73</td>
<td></td>
</tr>
<tr>
<td>ImR2: Patent</td>
<td>.87</td>
<td>46.90</td>
<td></td>
</tr>
<tr>
<td>ImR3: License</td>
<td>.88</td>
<td>59.81</td>
<td></td>
</tr>
</tbody>
</table>

| TABLE 2: Descriptive statistics and construct inter-correlations (N = 171) |
|----------------|----------------|-----------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Rel | M | STD | MarR | ImR | MC | IC | PP | CP | FP |
|----------------|----------------|-----------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Mar. Res. (MarR) | .91 | 4.61 | 1.20 | .89 |
| Inn. Res. (ImR) | .92 | 4.31 | 1.09 | .72 | .87 |
| Mar. Cap. (MC) | .96 | 4.32 | 1.21 | .55 | .45 | .89 |
| Inn. Cap. (IC) | .89 | 4.64 | 1.18 | .56 | .43 | .67 | .84 |
| Pro. Per. (PP) | .91 | 4.20 | 1.28 | .62 | .66 | .65 | .60 | .96 |
| Cus. Per. (CP) | .90 | 4.47 | 1.26 | .59 | .58 | .63 | .61 | .83 | .95 |
| Fin. Per. (FP) | .90 | 4.32 | 1.31 | .64 | .64 | .61 | .62 | .86 | .80 | .95 |

Hypothesis Testing

This study used Partial Least Squares (PLS) to test the proposed hypotheses. The bootstrapping procedure as outlined by Brown and Chin [63] for testing the proposed hypotheses was undertaken. Test of significance of all paths was performed on the basis of 500 bootstrapping runs as suggested by Chin [64] and others.

This study followed Baron and Kenny's [65] procedure and estimated in total 12 models in testing the hypotheses. According to Baron and Kenny [65] to establish mediation, four conditions must hold: (1) the independent variable must affect the dependent variable; (2) the independent variable must affect the mediator; (3) the mediators must affect the dependent variable; and (4) when mediators are entered into the model, the contribution of a previously significant independent variable must drop substantially for partial mediation and become insignificant for full mediation.

To test hypothesis 1a, which predicts that product performance mediates the effect of R-C innovation on financial performance we developed Model 1 and Model 2. As shown in Table 3, R-C innovation positively influences financial performance (Model 1, $\beta=0.34$ t-value=4.16) and product performance (Model 2, $\beta=0.30$ t-value=3.84), which also positively influences financial performance (Model 2, $\beta=0.83$ t-value=34.08). Comparing Models 1 and 2, this study found that the positive effect of R-C innovation in Model 1 becomes significantly weaker in Model 2 ($\beta=0.34$ vs. $\beta=0.10$). Therefore, product performance partially mediates the relationship between R-C innovation and financial performance, supporting hypothesis 1a. To test hypothesis 1b, which predicts that customer performance mediates the effect of R-C innovation on financial performance, this study developed Model 3. As shown in Table 3, R-C innovation positively influences financial performance (Model 1, $\beta=0.34$ t-value=4.16) and customer performance (Model 3, $\beta=0.29$ t-value=3.45), which also positively influences financial performance (Model 3, $\beta=0.77$ t-value=21.52). Comparing Models 1 and 3, this study found that the positive effect of R-C innovation in Model 1 becomes significantly weaker in Model 3 ($\beta=0.34$ vs. $\beta=0.11$). Therefore, customer performance partially mediates the relationship between R-C innovation and financial performance, supporting hypothesis 1b.

To test hypothesis 2a, which predicts that customer performance mediates the effect of R-C marketing on financial performance, this study developed Model 4 and Model 5. As shown in Table 3, R-C marketing positively influences financial performance (Model 4, $\beta=0.38$ t-value=4.81) and customer performance (Model 5, $\beta=0.31$ t-value=3.68), which also positively influences financial performance (Model 5, $\beta=0.82$ t-value=33.14). Comparing Models 4 and 5, this study found that the positive effect of R-C marketing in Model 4 becomes significantly weaker in Model 5 ($\beta=0.38$ vs. $\beta=0.13$). Therefore, customer performance partially mediates the relationship between R-C marketing and financial performance, supporting hypothesis 2a. To test hypothesis 2b, which predicts that product performance mediates the effect of R-C marketing on financial performance, this study developed Model 6. As shown in Table 3, R-C marketing positively influences financial performance (Model 4, $\beta=0.38$ t-value=4.81) and product performance (Model 6, $\beta=0.29$ t-value=3.60), which also positively influences financial performance (Model 6, $\beta=0.75$ t-value=24.04). Comparing Models 4 and 6, this study found that the positive effect of R-C marketing in Model 4 becomes significantly weaker in Model 6 ($\beta=0.38$ vs. $\beta=0.16$). Therefore, product performance partially mediates the relationship between R-C marketing and financial performance, supporting hypothesis 2b.

To test hypothesis 3a, which predicts that product performance mediates the effect of the interaction between R-C innovation and R-C marketing on financial performance, this study developed Model 7 and Model 8. As shown in Table 3, the interaction between R-C innovation and R-C marketing positively influences financial performance (Model 7, $\beta=0.24$ t-value=2.35) and product performance (Model 8, $\beta=0.20$ t-value=2.10), which also positively influences financial performance (Model 8, $\beta=0.84$ t-value=43.72). Comparing Models 7 and Model 8, this study found that the positive effect of the interaction between R-C innovation and R-C marketing in Model 7 becomes insignificant in Model 8 ($\beta=0.24$ vs. $\beta=0.07$). Therefore, product performance fully mediates the relationship between the interaction between R-C innovation and R-C marketing and financial performance, supporting hypothesis 3a. To test hypothesis 3b, which predicts that customer performance mediates the effect of the interaction between R-C innovation and R-C marketing on financial performance, this study developed Model 9. As shown in Table 3, the interaction between R-C innovation and R-C marketing positively influences financial performance (Model 7, $\beta=0.24$ t-value=2.35) and customer performance (Model 9, $\beta=0.17$ t-value=2.05), which also positively influences financial performance (Model 9, $\beta=0.78$ t-value=34.67). Comparing Models 7 and Model 9, this study found that the positive effect of the interaction between R-C innovation and R-C marketing in Model 7 becomes significantly weaker in Model 9 ($\beta=0.24$ vs. $\beta=0.10$). Therefore, customer performance partially mediates the relationship between the interaction between R-C innovation and R-C marketing and financial performance, supporting hypothesis 3b.

This study also conducted Sobel's [66,67] test to determine whether the mediating variables carried the effect of the independent variable on the endogenous variables. Significant t-values indicate that product performance and customer performance are critical mediators of the linkages between R-C innovation, R-C marketing, the interaction between R-C innovation and R-C marketing and financial performance.

Hypothesis 4a predicts that product performance has a stronger meditational role on R-C innovation – financial performance relationship than customer performance. Comparing Models 1, 2 and 3, this study found that the positive effect of R-C innovation in Model 1 drops more significantly in Model 2 ($\beta=0.34$ vs. $\beta=0.10$) than in Model 3 ($\beta=0.34$ vs. $\beta=0.11$). Therefore, hypothesis 4a is supported. To further support Hypothesis 4a this study developed Model...
achieve superior financial performance [16]. More importantly, little if any research has adopted the approach pursued here. This study contributes significantly to the literature which to-date has not empirically investigated the nature of complementary resource-capability combination in contributing to superior financial performance [69].

Extending [16] argument, the findings also go some ways in supporting the view drawn from asset orchestration literature by Sirmon and Hitt [17] that superior firm performance is achieved not only when resources and capabilities are deployed in combination but also when resources and the processes by which these resources are deployed are fit or complementary. As such, our advice to managers is that firms must possess superior level of resources coupled with complementary superior capabilities to deploy these resources to be successful in the marketplace because these resources and capabilities are intricately linked and inter-dependent and will not produce any value if deployed in isolation.

Second, identifying R-C innovation and R-C marketing as the key areas firms must be good at to achieve superior financial performance helps reaffirms the conventional wisdom by Drucker [18] that innovation and markets are the two key areas that enable firms to be successful in the marketplace. Unlike previous scholars who have put innovation capability [21] and marketing capability [19,20] at the forefront for firms achieving superior financial performance, the findings of this study address R-C marketing and R-C innovation in achieving superior financial performance via the ability to achieve product and customer performance outcome from R-C combinations.

The findings that R-C innovation and R-C marketing interact to achieve superior financial performance go beyond the works of Morgan et al. [19], Mizik and Jacobson [34], Moorman and Sotlegraff [35], Song et al. [36], and Menguc and Auh [70] who have dealt with the role of complementary capabilities in gaining marketplace advantage. The findings also provide an important theoretical and empirical contribution to the current literature which has to-date failed to identify the role resource-capability combinations within specific areas in achieving performance outcomes, as well as their potential to interact with one another between areas to create synergy in achieving superior performance in the form of financial outcomes (e.g., profits and return on investment). The findings not only underscore the individual contribution of R-C innovation and I-R marketing, but also lend support for the financial performance impact of the beneficial interaction between the two important areas via product and customer performance outcome. Marketing allows firms to understand customer needs and link with them. In return, innovation allows firms to transform these customer needs into quality products that then can be leveraged to satisfy and retain customers to achieve financial performance goal. The value of innovation is contingent upon effective understanding of customer needs and linking with customers via marketing. Extending the view of Teece et al. [5] and Vorhies et al. [20], the findings contribute significantly to the literature by suggesting that some firms may outperform others not only because they possess a specific individual resource-capability combination, but also because they possess...
resource-capability combinations that are complementary to each other and are characterized as possessing asset interconnectedness which is extremely hard for competitors to imitate. This study takes the view that firms need a balanced approach to developing and managing these two key areas to achieve optimal results in financial performance via product and customer performance. The findings of this study reinforce the necessity for a balance between innovation and marketing in reaping specific performance outcomes that will eventually lead to superior financial performance. The interaction effect between the two compared to the independent effect of each is a critical issue that needs further attention. As such, firms may consider specific performance objectives that can help firm achieve superior financial performance by considering both innovation and marketing synergy.

Third, the findings of the meditational roles of product and customer performance in facilitating complementary resource-capability combinations within and between innovation and marketing areas to achieve superior financial performance contribute significantly to the literature by addressing concern raised by Ray et al. [8] that linking firm’s resources and capabilities directly to firm’s financial performance may lead to misleading conclusions. It is because some firms may possess superior in some resources and capabilities and inferiority in others and more importantly firms that possess specific resources and capabilities may achieve more in specific marketplace performance outcomes. The findings also advance our understanding the role of performance at a micro-level and macro-level by identifying that firms that achieve superior product performance gain superior financial performance as a result. Similarly, firms that achieve superior customer performance also gain superior financial performance as a result. As such our advice to managers is that they may prioritize performance goals at a micro-level by delivering more product choices to meet customers’ demand [12] and serving customers better than their rivals [11]. Even though such a focus for managers may be costly [8] firms will gain subsequent financial performance in increasingly competitive environments.

Fourth, the findings that product performance has a stronger meditational role on R-C innovation – financial performance relationship than customer performance as well as the findings that customer performance has a stronger meditational role on R-C marketing – financial performance relationship than product performance help verify the argument by Ray et al. [8] and Newbert [69] that particular resources and capabilities may contribute differently to particular performance outcomes at disaggregated levels. This study shows that resources and capabilities associated with innovation contribute more significantly to product performance while resources and capabilities associated with marketing contribute more significantly to customer performance. As such, our advice to managers is that if firms seek to achieve superiority in product performance, firms need to give increased consideration to developing superior innovation resources and innovation capability. On the other hand, if firms seek to achieve superiority in customer performance, firms need to give increased consideration to developing superior marketing resources and marketing capability.

LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

The findings of this study should be considered in the light of specific limitations. First, even though the approach adopted in this study to measuring firm resources, capabilities and firm performance is in line with the existing literature [19,20,51,54], we realize that the cross-sectional data employed in this study may not provide the same insight into the dynamics of the complementarity within marketing resources-capability area, and complementarity within the innovation resources-capability area, and product, customer and financial performance relationships as would a longitudinal design. Hence, future research using longitudinal data may help evaluating the prescribed order of investment in developing the relationships among innovation resources, marketing resources, innovation capability, marketing capability, product performance, customer performance and financial performance. Second, this study focuses on SMEs in emerging country (Cambodia). Future research may focus on large firms in emerging countries or developed countries to help prove the validity of the model being studied. Third, drawing on RBV, this study focuses on R-C innovation and R-C marketing and their complementarity. Future research may take into account the role of R-C learning since it is argued that firms that possess abilities to analyse their unsuccessful business operations in areas such as innovation and marketing can improve their product offerings and serve customers better in a long run [52]. This approach may also be extended to bring a broader set of R-C combinations by focusing on areas such as operations, technology and the like. Fourth, the results are also limited in the context of the single and perceptual view of managers in measuring product, customer and financial performance. Future research may attempt to measure customer performance in terms of both firm and customer perceptions, product performance in terms of both firm and competitor perceptions, and financial performance in terms of both subjective and objective data.

REFERENCES


Phyra Sok and Aron O’Cass


Phyra Sok and Aron O’Cass


**TABLE 3: Hypotheses 1 and 2: Structural Equation Parameter Estimates (t-value)**

<table>
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<tr>
<th>Independent variables</th>
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Control Variables

| Firm age              | .04           | .05           | .05           | .04           | .05           | .04           |
|                       | (0.40)        | (0.92)        | (0.91)        | (0.46)        | (0.85)        | (0.87)        |
| Firm Size             | .16           | .02           | .02           | .15           | .02           | .02           |
|                       | (1.74)        | (0.48)        | (0.27)        | (1.64)        | (0.30)        | (0.43)        |
| Industry Type         | .01           | .02           | .05           | .01           | .05           | .03           |
|                       | (0.19)        | (0.48)        | (0.95)        | (0.16)        | (1.18)        | (0.70)        |
| Technology Uncertainty| .01           | .03           | .07           | .04           | .03           | .04           |
|                       | (0.19)        | (0.76)        | (1.50)        | (0.48)        | (0.62)        | (0.95)        |
| Market Uncertainty    | .11           | .00           | .09           | .11           | .07           | .00           |
|                       | (1.40)        | (0.08)        | (1.66)        | (1.53)        | (1.55)        | (0.01)        |
TABLE 3 (Con’t): Hypotheses 3 and 4: Structural Equation Parameter Estimates (t-value)

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VIRTUAL RESOURCES THEORY

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ABSTRACT

Resource-based view theory focuses on resources within the organisation, under its direct control. Evidence for the existence of virtual strategic resources was identified in the automotive, aerospace, banking and software industries. Conditions for an external strategic resource included being non-transferable, existing in a complementary structure, linked to complementary products or processes, knowledge-oriented, facilitated by social and power relationships, and able to be developed under network conditions. Constructs that linked internationalisation theory, actor-network theory and agency theory to the management of virtual resources were identified. Key locations identified for virtual resources were within the organisation's supply chain and within non-associated industries.

Keywords: resource-based view, business performance

INTRODUCTION

Barney's (1991) resource-based view (RBV) of business level performance was developed based on a foundation of corporate planning perspectives. It represented a new way of looking at opportunities for improving business level performance and explaining the performance differences between organisations experiencing the same external environment. It described the characteristics of the organisation and how they function and contains few behavioural assumptions [42]. One of the few exceptions, implicit in the characteristics of strategic resources identified by Barney and others (e.g. [5, 27, 1, 13, 7, 14]) as well as the constructs which have been developed or the RBV (described in detail below), is the assumption that the organisation directly controls its strategic resources [42]. The assumption that a Ricardian rent can only be extracted from resources in the control of the organisation [46, 58] is inconsistent with observable behaviour. Organisations may extract rent from sources that they do not own [56]: one example would be the use of third-party knowledge in product innovation.

Changes to typical industry structures, the increasing role of the Internet and globalisation have led to a change in the location of strategic resources. For example, the automotive industry in almost every country has transferred responsibility for the bulk of their R&D activities to their suppliers. Long considered to be a strategic resource in this industry, R&D which results in vehicle improvement such as new features and performance, results from the R&D capabilities of the component suppliers of the industry. This industry now concentrates on its ability to manage suppliers to have the best access to the best R&D possible [57]. This paper presents a perspective on the resource-based view which incorporates the dimension that strategic resources may be located outside the direct control of the organisation, yet still contribute significantly to that organisation's performance.

This perspective is particularly consistent with other contemporary strategic management perspectives including network and agency theory. Agency theory takes an economic view of business control and suggests that the choices managers make can be influenced by punishment and rewards, to ensure that manager’s goals are congruent with the owner’s goals [18]. The RBV can be coupled with agency theory to provide better explanations of strategic behaviours where virtual resources exist. For example, a study of 439 franchisors determined that franchisors decreased the proportion of franchisees as they grew, due to the increasing scarcity of resources to sufficiently support the business within the organisation, but increased the proportion of franchisees over time as they became more confident of the agency relationship with their franchisees [10] and, so, were able to access resources outside the organisation (amongst the franchisees). In a similar manner, the RBV can be combined with institutional theory to explain strategic behaviours. Institutional theory correctly predicts that an institution can develop trust to create a useful endogenous resource among staff for the development of desirable resources. For example, resources developed in this manner have been found to lead to quality-based competitive advantage [35].

From the resource-based perspective, this enables the development of strategic resources to be encouraged through the use of appropriate control mechanisms. Where the resources are virtual, however, it may not be possible for owners to apply control mechanisms with the same degree of effectiveness. Also, the more separate the ownership of the organisation, the greater the agency costs associated with aligning manager's goals with the owner’s goals [18]. The existence of virtual resources means that the effectiveness of these controls for an organisation’s resource development would be lower and so the agency costs would rise more quickly with increasing owner separation. This construct is not incorporated in the resource-based view at present. If organisational performance is substantially a reflection of the utilisation of strategic resources, agency theory may not be valid under situations where significant proportions of virtual resources are utilised.

Actor-network theory suggests that knowledge is constructed by a heterogeneous network of people and mechanisms [68]. It adds a decision-making dimension to the role of resources in the organisation and a dynamic characteristic [42]. Actors in networks as creators of specialised knowledge are, therefore, important drivers of the development of strategic resources [8], confirming the likely existence of valuable virtual resources where those
The paper will provide a review of the theory that led to the resource-based view, including the definitions of a strategic resource and the constructs that have been developed around that view. It will then consider evidence from a number of industries that supports the existence of strategic resources that contribute significantly to business level performance that lie outside the control of the organisation. It will then propose a new set of definitions for the strategic resources outside the direct control of the organisation (virtual resources) and some of the constructs that are likely to apply, and address their external validity through support from network and agency theory.

LITERATURE REVIEW

The contribution of the RBV to explaining variations in organisational performance is considerable compared to the explanatory value of other models, such as Porter's 1980s perspective on the role of industry determining profitability for the organisation. In the mid-1990s, a four-year longitudinal study of 2800 US businesses determined that, whilst industry conditions explained 4% of profitability variation, individual company resources could explain 44% of profitability variation across companies [65]. A more recent study in Spain involving 1642 organisations, found that industry conditions explained 3% and company resources explained 36% of performance variation [44].

Despite its obvious contributions, the RBV literature has provided very limited empirical testing of its ability to predict Competitive Advantage (CA) and the literature calls for the development of constructs though which it can be applied; as will be demonstrated.

The RBV contains elements of the structure and cost (economics) theories of the determinants of performance in an industry [7]. It also contains components of Industrial Organisation (IO) theories, such as the economic models of perfect competition and transaction cost theory, but rejects other elements making it independent of existing IO theories [15]. Its development was also strongly influenced by the work of Penrose, representing a further departure from mainstream IO theory [40].

The RBV theory development commenced with the work of economists such as Chamberlain, as early as the 1930s, evolved through the contributions of strategy researchers, such as Ansoff, in the 1960s and 70s, and was formalised through a prodigious volume of conceptual development of the topic in the late 1980s [23]. Barney's 1991 explanation of the RBV postulates that a CA can be derived from resources and capabilities that are valuable, rare, difficult to imitate and not substitutable [6]. The RBV has provided a very useful taxonomy for the analysis of the contribution of specific business disciplines to organisational value creation, such as human resource management [76], entrepreneurship and international business literature, and some contributions to the economic literature in the areas of causality [6].

At the time of Barney’s work, resources were identified as physical, human or organisational. Since then RBV theory has been extended by the addition of the dynamic capabilities perspective (the development of the ability to apply resources to create a CA), and the knowledge perspective (which integrates organisational learning) [44, 53]. Many subgroups of resources have also been identified [23]. More recent research has focused on the impact of the management skills available in the organisation to control the conversion of resources into CA [23]. Research in this area has identified skills, processes and assets as possible leverages (capabilities) for converting resources into a CA [53]. Recent research involving 164 organisations determined that CA for manufacturing can result from proprietary processes and specialised equipment which can only be acquired using knowledge gained from internal and external sources [66]. This suggests that knowledge may actually form part of a barrier to substitution through imitation, and supports the rarity criteria proposed by Barney.

Table 1 below shows the various criteria recommended by Barney and other selected researchers. The difference between these sets of criteria is quite small. Barney's four criteria set is the more suitable for the empirical research discussed in this paper because of the simplicity, clarity of definition and scope of coverage of the criteria. Grant's criteria focus more on the internal management perspectives and do not include the value that the resources create. Internal management perspectives will be considered in this research as research variable focus criteria, Collis and Montgomery's [14] criteria are essentially the same as Barney's [7], except for the addition of durability. Durability is a second order criterion which, whilst clearly contributing to the long-term viability of the organisation, is less important from the research perspective than the creation of value. It can also be argued that the durability criterion is represented by the criteria value. Amit and Schoemaker's [1] criteria overlap with Barney's [7] criteria, with the exception of durability and complementarity. Durability has been identified as a second order criterion, and complementarity is considered to be more appropriately measured as a research variable focus criterion, rather than as a resource criterion. For this reason, Barney’s criteria were adopted as the independent variables for this research. Complementarity is considered as one of the research variable focus criteria, and durability is considered in the discussion for the time dimension it contributes as it is clearly identified in Barney's criteria.

Barney's criteria were adopted as the independent variables for this research, although the term durability is also considered later in this paper, as it introduces a time dimension less emphasised by Barney's criteria.

The 11th International DSI and the 16th APDSI Joint Meeting, Taipei, Taiwan, July 12 – 16, 2011, pp. 63-73
Although there has been some good conceptual RBV development, researchers agree that empirical examination of the RBV has been inadequate to identify the relationship between the characteristics of resources and capabilities when CA is created (constructs), or the ability to use it to predict or control the creation of CA [23, 44, 2, 41, 46, 68]. Most of the RBV empirical research to date has been focused on isolated areas of business operations and has led to few generalisable and unifying conclusions regarding the application of RBV theory. Unquestionably, further empirical research in this area is required to fully explore the unifying capability of RBV theory [15, 42, 46, 56, 68]. Such research should consider the organisation in its entirety and investigate one (or more) single bounded industries so that the impact of variations between local environments and across industries (even if this factor is small), is eliminated. In this way, the empirical research findings are more likely to be generalisable (so as to identify support for the RBV) [25] and create the necessary constructs for different contexts and industries [74, 39].

The empirical RBV research to date has determined that the capability to utilise resources for CA is affected by the efficiency of the business unit operations and corporate decision-making processes [54, 63, 46]. This finding supports the importance of investigating the impact of management skills noted earlier. The impacts of capabilities are difficult to separate when considering outputs as the dependent variable, so it is better to view the capability process from the management and the operations perspectives individually [63, 3].

A study of a cluster of Brazilian wine producers determined that clusters could also share the resources and the capabilities necessary to gain a CA [74]. Not unexpectedly, the research also identified that cognitive mapping of the resources and capabilities of the cluster provided an improved management understanding of how to increase the efficiency of the cluster's capability to transform resources to a CA. Particular resource categories identified were knowledge, technology and production control, and contractual skills. The capabilities identified as necessary to sustain CA included organisational learning and non-codified expertise, long-term investment in technology and staff, long-term investment in cluster resources (such as research institutes and training colleges), complexity, information asymmetries and specialisation [74].

Research into the US retail food industry determined that a general dynamic capability could affect the application of some resources (such as supply chain management skills), but did not affect other resources (such as environmental management skills). In this instance, external factors were found to affect the application of the environmental management skill resource, although the participants did not view environmental management as a resource that could create a CA [47]. Another US food retailer study found that ignoring the interdependencies between up and down stream competencies and the environment affected the overall level of CA achieved [69].

### Problems with RBV theory

Selection of the correct empirical research methodology to enable the identification of specific resources meeting Barney's criteria and separation of the contributions of these resources to CA, has proven to be one of the difficulties associated with empirical research into the RBV [42]. Industries need to be very homogenous to enable fair comparisons to be made across organisations, and resources can be difficult to identify as many are intangible [23, 44, 63, 2]. Given the definition of valuable resources shown in Table 1, the logical conclusion is that the very best resources will be the hardest to identify [23]. Furthermore, such resources must also be very difficult to attain in the first place [53]. The literature suggests that such resources need to be identified using qualitative methods [64].

Barney's (1991) VRIN framework (value, rarity, irreversibility and non-substitutable), and Barney’s (1996) subsequent VRIO framework (value, rarity, inimitability and organizational appropriability), do not provide a strong measure of the potential for performance, as even resources which are relatively weak according to this metric still correlate with the significant sustained superior performance [3]. This may be partially due to limited attention being given to date to the selection of the correct output variables. Further development of the constructs representing the impact of CA is required for investigation of the RBV. For example, a RBV study of US organisations found that measuring the net value achieved by the resources was a better approach than many of the previous studies which had only considered accounting profit [63].

In addition, the theory does not adequately consider how organisations establish the resources to create CA [49]. Such resources must also be very difficult to attain in the first place [53] and may be explained by linkage, resource leverage and learning [49]. With these characteristics, the resources that are most likely to be targeted for development would most likely be those that are also the least rare, most imitable and most easily transferred [50], as less effort would be required to develop and acquire them. Organisations need to mix internal resource development and external resource acquisition to maximise their dynamic control and minimise the costs.

<table>
<thead>
<tr>
<th>Resource Criteria</th>
<th>Researcher</th>
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<tbody>
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<td>Value, rareness, inimitability and non-substitutability</td>
<td>Barney [5, 7]</td>
</tr>
<tr>
<td>Durability, transparency, transferability and applicability</td>
<td>Grant [27]</td>
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<tr>
<td>Inimitability, durability, appropriability, substitutability and competitive superiority</td>
<td>Collis and Montgomery [13, 14]</td>
</tr>
<tr>
<td>Complementarity, scarcity, low tradeability, inimitability, limited substitutability, appropriability, durability and overlap with strategic industry factors</td>
<td>Amit and Schoemaker [1]</td>
</tr>
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</table>

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Selection of the correct empirical research methodology to enable the identification of specific resources meeting Barney's criteria and separation of the contributions of these resources to CA, has proven to be one of the difficulties associated with empirical research into the RBV [42]. Industries need to be very homogenous to enable fair comparisons to be made across organisations, and resources can be difficult to identify as many are intangible [23, 44, 63, 2]. Given the definition of valuable resources shown in Table 1, the logical conclusion is that the very best resources will be the hardest to identify [23]. Furthermore, such resources must also be very difficult to attain in the first place [53]. The literature suggests that such resources need to be identified using qualitative methods [64].

Barney's (1991) VRIN framework (value, rarity, irreversibility and non-substitutable), and Barney’s (1996) subsequent VRIO framework (value, rarity, inimitability and organizational appropriability), do not provide a strong measure of the potential for performance, as even resources which are relatively weak according to this metric still correlate with the significant sustained superior performance [3]. This may be partially due to limited attention being given to date to the selection of the correct output variables. Further development of the constructs representing the impact of CA is required for investigation of the RBV. For example, a RBV study of US organisations found that measuring the net value achieved by the resources was a better approach than many of the previous studies which had only considered accounting profit [63].

In addition, the theory does not adequately consider how organisations establish the resources to create CA [49]. Such resources must also be very difficult to attain in the first place [53] and may be explained by linkage, resource leverage and learning [49]. With these characteristics, the resources that are most likely to be targeted for development would most likely be those that are also the least rare, most imitable and most easily transferred [50], as less effort would be required to develop and acquire them. Organisations need to mix internal resource development and external resource acquisition to maximise their dynamic control and minimise the costs.
associated with causal ambiguity and time compression diseconomies [50]. This would create a complex resource management and development process which may be integrated with other activity development processes.

Criteria for empirical testing of the application of RBV

The following criteria for empirical testing of the application of RBV were extracted from the literature review above and have been classified under the following three headings:

Theory Evaluation Criteria:
1. Measurement of the benefit predicted by the RBV theory [2].
2. Generalisation of empirical findings to support RBV [25].
3. Production of contextual constructs from findings [39].

Research Variable Focus Criteria:
4. Treatment of resources as an input to advantage (to avoid the circular definition of advantage in identifying the resources that created it as valuable) [23].
5. Consideration of the process of the development of the resources (time compression diseconomies, interconnectedness, scales of mass efficiency, causal ambiguity and the resource development trajectory relative to industry conditions can affect the contribution that these resources actually make) [23, 49].
6. Identification of the use of management control to convert the resource to customer-perceived value [23].
7. Consideration of multiple resources when complementary resources need to be integrated with core resources [69].
8. Measurement of impact of management, process, regional and scale effects on the capability to utilise resources to create a CA [63].
9. Differentiation of use of internal development versus external acquisition as a measure of maturity of resource development for CA (considering the time compression diseconomies and causal ambiguity effects associated) [50].
10. Identification of individual resource criteria evaluation techniques [50].

Specific Findings Criteria:
11. Explanation of performance differences between organisations on the basis of asset differences [15].
12. Identification of the causal structure of resources (capability is difficult to copy because it takes time, even if the resource is acquired) [23, 53].
13. Explanation of how resources can be used to create competitive heterogeneity [53].

The literature review above shows that (a) the definition of strategic resources identified in the literature focuses on features that only internal business characteristics would possess, and (b) the constructs that have been developed around the theory predominantly deal with approaches to management of the application and development of strategic resources that are internal to the organisation. The contemporary literature suggests that organisations utilise resources outside the organisation, over which they have limited control, both by design and by accident [75, 62].

It is interesting to consider the fact that the difficulties in developing constructs for the application of the resource-based view, despite its demonstrated ability to explain differences in performance between organisations operating in the same external environment, have long been identified [42, 3, 46]). This may reflect the fact that investigations into the explanatory power of the RBV for organisational performance were most extensive in the late 1990s when the impact of changes to industry structure, globalisation and the Internet were already in play. A few empirical studies [20] that identified the importance of external resources were already being published by the mid-1990s. It may be that the emerging presence of virtual resources caused the focus of developing constructs, using only an internal focus, to be invalid as an adequate explanation of how organisations perform in the external environment (industry). Had a broader perspective on the location of strategic resources been incorporated in the earlier research, a range of more valuable constructs may have been identified.

With these observations in mind, the research question identified is "should the definition of resources for the RBV be extended to include virtual resources". This research question meets four of the research criteria identified above, namely:

2. Generalisation of empirical findings to support RBV [25]
5. Process of the development of the resources
8. Measurement of impact of management, process, regional and scale effects on the capability to utilise resources to create a CA
9. Differentiation of use of internal development versus external acquisition as a measure of maturity of resource development for CA (considering the time compression diseconomies and causal ambiguity effects associated)

METHODOLOGY

A meta-analysis of the literature was conducted to identify data regarding the impact on business performance of strategic resources located outside the organisation in four industries; automotive, software, aerospace and banking. These industries were selected on the basis of their global scale and the existence of evidence regarding virtual resources. A review of industry reports for each of the selected industries was conducted to identify the terminology associated with virtual resources in the literature related to these industries. These terms were then utilised in a meta-analysis of all scholarly journals regularly publishing articles on the selected industry, utilising three abstracts in databases. An analysis of all journals containing the identified search terms and data on the selected industries resulted in response rates below 0.1% across the databases. Therefore, only journals regularly publishing research on the identified industries were considered to be useful data sources.
FINDINGS

The following findings present empirical evidence from the literature which describes some constructs and the impact of business performance on the use of strategic resources located outside the organisation [75, 9, 62, 59]:

Automotive industry

The response rate for this meta-analysis was:

<table>
<thead>
<tr>
<th>Database Title</th>
<th>Number of Articles</th>
</tr>
</thead>
<tbody>
<tr>
<td>EBSCO Academic and Business</td>
<td>5</td>
</tr>
<tr>
<td>Source Complete</td>
<td></td>
</tr>
<tr>
<td>Science Direct</td>
<td>0</td>
</tr>
<tr>
<td>ABI/Inform Complete</td>
<td>8</td>
</tr>
</tbody>
</table>

Three articles overlapped in two database sources.

A strong demand chain relationship exists within the automotive industry which limits this industry's access to virtual resources located within its suppliers. Where suppliers are able to achieve balanced power relationships due to arrangements such as co-development agreements, greater access to virtual resources prevails [17]. As with the aerospace industry considered below, the automotive industry appears to be better able to access knowledge-type virtual resources, but only amongst suppliers [52]. Companies in the industry with a more formalised demand chain approach to managing suppliers were also able to gain less competitive advantage from virtual knowledge-based resources [24, 21]. This approach may apply predominantly to companies operating in the developed economy sector of the industry.

Companies in segments of the industry in emerging economies, by comparison, have been found to use social capital among networks to access virtual resources and manage the relationships that affect those resources [38]. In emergent economies, the ability to integrate virtual (and internal) resources is more strongly associated with organisational performance than the overall level of resources the company possesses [71]. In the Indian automotive industry, a joint-venture between a local producer and Peugeot was well-supplied with strategic resources, but still proved to be unsuccessful. At the same time, a local company which was able to access and utilise a more limited range of local virtual resources was successful [72]. In the Chinese automotive industry, companies are gaining a competitive advantage through higher levels of innovation than are normally found in the industry as they make greater use of the virtual resources available to them in China [73].

The more dynamic the external environment, the greater the competitive advantage that organisations in this industry can gain from virtual resources [48]. One of the advantages of using virtual resources for companies operating in more dynamic segments of this industry is that capital becomes available for other activities [59]. It also facilitates a greater rate of internationalisation in dynamic environments [61].

Software industry

The response rate for this meta-analysis was:

<table>
<thead>
<tr>
<th>Database Title</th>
<th>Number of Articles</th>
</tr>
</thead>
<tbody>
<tr>
<td>EBSCO Academic and Business Source Complete</td>
<td>1</td>
</tr>
<tr>
<td>Science Direct</td>
<td>0</td>
</tr>
<tr>
<td>ABI/Inform Complete</td>
<td>7</td>
</tr>
</tbody>
</table>

No articles overlapped any sources.

Knowledge is a resource that is frequently transferred amongst industry clusters and is an important contributor to innovation as a competitive advantage [16]. A related virtual resource is external R&D skills integrated into external arrangements [51]. The strategic resource of knowledge is shared by cluster members in the software industry so that it provides a competitive advantage to the cluster, relative to other software industry clusters. The importance of sharing this virtual resource amongst the cluster members is sufficient to be a defining factor in the membership of clusters [16]. Lavie [36] identified the importance of resources existing within networks for the performance of companies in the US software industry. The ability to make use of the resources is affected by the bargaining power of the organisation relative to the more powerful partners in the network, and the level of industry competition amongst the network members [36].

Virtual resources have also been found to increase industry competition by increasing the resource availability for complementary products produced by other organisations, increasing the competitiveness of the original product and stimulating rivalry amongst competitors [37]. The proportion of virtual resources organisations utilised in this industry is strongly affected by the structure of the organisation and its business level strategy [62]. In terms of geographical coverage, virtual resources in the software industry tend to be located at the regional level to commence with, and are more likely to be found in the international market as the organisation develops [43].

Banking industry

The response rate for this meta-analysis was:

<table>
<thead>
<tr>
<th>Database Title</th>
<th>Number of Articles</th>
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</thead>
<tbody>
<tr>
<td>EBSCO Academic and Business Source Complete</td>
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</tr>
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<td>Science Direct</td>
<td>2</td>
</tr>
<tr>
<td>ABI/Inform Complete</td>
<td>5</td>
</tr>
</tbody>
</table>

No articles overlapped any sources.

The banking industry has long relied on virtual resources to reduce operating costs [4, 12] and free-up capital for other activities [11]. The effective use of virtual resources is particularly significant for the achievement of competitive advantage amongst small banks where technical resources and capital are particularly limited [32, 55, 70]. Innovation in emergent segments of the industry, such as Internet banking, is frequently the result of accessing virtual strategic resources [9]. In the Japanese
banking industry, the use of virtual strategic resources has resulted in higher levels of technology-based innovations that are applicable across the industry in general [29]. Companies in this industry have also taken advantage of virtual resources specific to locations in which they do not operate to gain competitive advantage [33], and to gain a competitive advantage from access to superior market information [34].

**Aerospace industry**

The response rate for this meta-analysis was:

<table>
<thead>
<tr>
<th>Database Title</th>
<th>Number of Articles</th>
</tr>
</thead>
<tbody>
<tr>
<td>EBSCO Academic and Business Source Complete</td>
<td>1</td>
</tr>
<tr>
<td>Science Direct</td>
<td>0</td>
</tr>
<tr>
<td>ABI/Inform Complete</td>
<td>6</td>
</tr>
</tbody>
</table>

No articles overlapped any sources.

The structure of relationships with other organisations determines the proportion of resources and organisation this industry is able to access [20]. Knowledge is an important strategic resource for this industry and, whilst the capability to maintain and gain a competitive advantage from this resource was found to be strongly linked to organisational performance in this industry, the location of the resource (internal virtual) was not [22]. This suggests that organisations in this industry are equally able to gain a competitive advantage from a virtual resource as they are from an internal resource. On the other hand, it was also found that companies in this industry were less able to gain a competitive advantage from virtual resources where they had to modify their relationship with key external organisations, such as suppliers, in order to access those resources [26]. This industry uses demand to drive its supply chains and so suppliers operate under highly-prescribed relationships [75]. The industry does not make extensive use of networks of cooperating industry members or producers of complementary products where resources are located in the network by mutual agreement.

This limited approach to accessing virtual resources was present in the 1980s and earlier [28]. It does not appear to have been intentional, but rather reflected the demand perspective identified by Williams, resulting from a strong focus on customer and internal resources, rather than the broader environment. Major customers, such as the US Department of Defence, were strong drivers of resource allocation in response to customer demand in some segments of this industry, driving companies away from considering resource location optimisation [45]. In addition to taking advantage of knowledge as a virtual resource, companies in this industry are better able to access virtual resources that lead to innovation as a competitive advantage. Companies in the jet engine manufacturing segment of the industry are more able to access virtual design and materials utilisation knowledge to introduce innovations into existing products and other segments of the industry [67].

**FINDINGS**

Virtual resources were primarily accessed from suppliers in both the automotive and aerospace industries. An internal and customer focus in the aerospace industry, and a reluctance to develop new network relationships, were the reasons for focusing primarily on suppliers for access to virtual resources. On the other hand, the banking and software industries freely accessed resources from non-connected industries.

Economic conditions influenced the nature and benefit of accessing virtual resources. Other external environmental conditions, such as industry dynamics, also influenced the amount of competitive advantage gained from virtual resources. The utilisation of virtual resources can increase availability of complementary products and so increase industry competition. Access to virtual resources influences the rate of internationalisation.

**Table 2. Constructs connecting virtual resources and actor-network theory**

<table>
<thead>
<tr>
<th>Construct</th>
<th>Automotive</th>
<th>Software</th>
<th>Banking</th>
<th>Aerospace</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Power relationships influence access to virtual resources</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>2. Social capital influences access to virtual resources</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Knowledge is a frequently-accessed virtual resource</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Organisations with fewer internal resources make more use of virtual resources</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Managers tended to rely on existing relationships with external organisations, such as suppliers, rather than searching for other types of organisations offering virtual resources. The structure of the organisation also influences the proportion of virtual resources that can be accessed. Smaller organisations possessed fewer internal resources and made more effective use of virtual resources. External R&D was incorporated into network arrangements, and knowledge sharing was used to create clusters around shared virtual resources, providing a competitive advantage to the cluster.

These findings led to seven constructs which were found to connect with either actor-network or agency theory. These constructs are shown in Tables 2 and 3.
The connection with internationalisation theory was unexpected, but logical, given the global scope and scale of the industries selected as data sources. The finding that the rate of internationalisation increases with access to virtual resources supports internationalisation theory [30] as one of the principal identified forms of external resources is knowledge, and understanding industries in other countries is one of the criteria for movement through the stages of internationalisation. This finding was predicted by the literature, with [31] noting that internationalisation networks were now an important part of internationalisation (although not identifying the mechanisms through which this occurs). This finding also supports OLI theory [19] in that accessing virtual resources means the organisation is able to access sources of competitiveness it can use in other industries.

The findings also indicate that many virtual resources are present in the organisation's supply chain. This is both an appropriate and intuitively attractive conclusion, as the external organisations which are most heavily relied upon are usually suppliers. In addition (and as a result), an organisation or business will invest the most effort in establishing partnerships that transfer advantage with key suppliers.

A further finding is that key resources can come from non-connected industries as well. From the management perspective, this suggests two very different locations for virtual resources: the business's supply chain and non-connected industries. The different approaches taken by organisations in accessing resources identified within the data, for supply-chain-located virtual resources and other virtual resources, support this observation. The constructs in the findings above have been expressed as the following set of virtual resource management practices for these two locations:

**Supply-chain-located virtual resources**

Management techniques for resources located in the supply chain would include:
1. Use of supply chain theory practices, such as technology park approaches, trust and communication
2. Use of supply chain development practices, such as lean operations and quality assurance to develop virtual resources present in the supply chain

**Non-typically associated industry-located virtual resources**

Management techniques for resources located in industries not normally associated with the business would include:

**Identification of potential locations for virtual resources**
1. Technology forecasting to identify where potential future strategic resources may be aggregating.
2. Industry analysis to identify global industries which are developing quickly and are performing well financially (for example, the resources industry) to

---

### Table 3. Connections between virtual resources and agency theory

<table>
<thead>
<tr>
<th>Construct</th>
<th>Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Automotive</td>
</tr>
<tr>
<td>5. Virtual resources access reflects manager rather than owner goals</td>
<td>X</td>
</tr>
<tr>
<td>6. The integration of virtual resources provides a greater impact on organisational performance in emerging economies</td>
<td>X</td>
</tr>
<tr>
<td>7. The structure of the organisation influences its ability to access virtual resources</td>
<td></td>
</tr>
</tbody>
</table>

**Connections with other theories:**

The rate of internationalisation is influenced by access to virtual resources in the software and banking industry.

**DISCUSSION**

The findings suggest a number of conditions for a virtual resource, which are neither exclusive nor compulsory:

1. Non-transferable
2. Existing in a complementary structure
3. Linked to complementary products/processes
4. Knowledge-oriented
5. Facilitated by social and power relationships
6. Able to be further developed under network conditions

The description of a virtual resource is also conditional on its qualifying as a resource, namely, meeting the characteristics of a resource as defined by Barney [7].

The identification of constructs for the utilisation of virtual resources that are consistent with actor-network and agency theory in Tables 2 and 3 indicates that both of these formative theories provide appropriate frameworks through which to view virtual resources. This is an important finding as it eliminates the criticism of the resource-based view (without virtual resources) of being tautological. The criticism of the standard resource-based view being tautological results from an economic perspective that resources which lead to improved organisational performance are defined by the fact that they create greater organisational performance [41]. In defining virtual resources as sources of advantage which are accessed from the external environment through network arrangements and which are affected by agency behaviours, a linear contribution of these resources to business performance is created.
identify industries capable of developing virtual resources of interest to the business.

3. Application of Porter's [60] Theory of National Competitive Advantage to identify other national industries which are sufficiently attractive to be potential locations of future virtual resources.

Management of virtual resources in unconnected industries

1. Use of OLI theory to identify attractive industries where company investment in modes, such as joint partnerships, could be utilised to stimulate continuing development and provide some degree of control over virtual resources.

2. Use of agency theory to identify the likely compliance of organisations and industries possessing virtual resources with the needs of the business.

3. Use of actor-network theory to strengthen cooperative relationships with ‘owners’ of virtual resources through third parties present in the network.

CONCLUSION

This research has identified the existence of strategic resources existing outside the organisation's direct control. Thus, the research question, "Should the definition of resources for the RBV be extended to include virtual resources?" has been answered in the affirmative.

The data suggested six characteristics for a virtual resource, which would add to the characteristics of an internal resource and which primarily reflect the location of the resource, and the organisational relationships affecting access to that resource. The research findings have also indicated that actor-network and agency theory are relevant to the management of virtual resources. Seven virtual resource constructs aligning with these two theories were identified from the data. In addition, one construct relating to internationalisation and OLI theory was identified.

The findings suggested two important locations for virtual resources when considering virtual resource management practices – virtual resources located within the organisation's supply chain, and virtual resources located within industries not directly connected to the organisation. The findings indicated that managing resources in these two different locations will require quite different management practices. Two management techniques for dealing with supply-chain-located virtual resources were developed from the identified constructs. Six management techniques were identified for virtual resources in industries not directly connected to the organisation (three for identifying location, and three for managing the resources).

There is enormous scope for further validation and development of VRT constructs, both within the supply chain and within non-associated industries. Empirical studies examining the contribution of virtual resources to the performance of organisations in specific industries would identify whether their contribution was the same as internally located resources. Empirical research around the eight virtual resource management techniques above would identify more constructs that could be used to identify and predict the development of virtual resources. Additional investigation of the role of virtual resources in internationalisation would identify further constructs around their role in this activity.

REFERENCES


AN EXPLORATORY STUDY ON THE DETERMINANTS OF SMARTPHONE APP PURCHASE

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Jung Eun Son, Yonsei University, Korea, jeson@yonsei.ac.kr

ABSTRACT

Along with the growth of the smartphone market, the furnishing of diverse and plentiful mobile Apps is surfacing as the key competitiveness of smartphones. The mobile App market has been appraised as a competitive new market carrying huge potential. Although many users download and use paid and free Apps from App Store and App Market, relevant research regarding consumer app buying is virtually non-existent. This study aims to examine the key determinants in deciding the purchase of Smartphone Apps. Because customers may have different consideration factors in deciding the purchase depending on the App type, we first classified Apps into 4 types: Productivity, Entertainment, Information, and Networking. With interviews with 30 App buyers, we identified the antecedents in the purchase of App in each type and compared them across the four types. This study has several implications for research and practice. Especially, the findings provide guidance to App developers and marketers in promoting the sales of App.

Keywords: App Store; App Market; mobile App; mobile business; purpose of buying.

INTRODUCTION

With the growth of the Smartphone market and along with it, the mobile app market, the overall market has been appraised as a competitive one. According to Figure 1, The worldwide smartphone app market is forecasted to grow from 6.8 billion US Dollars in 2010 to 92.5 billion US Dollars in 2013, roughly a four times increase [14].

Currently, apps registered at App Store are mostly of the mobile games and books categories; in the future, categories like Social Network Service (SNS) and mobile shopping are expected to grow significantly [4]. The term "app economy" has emerged, signifying the new economic landscape created by mobile apps. On the back of the rise of the smartphone, current momentum behind the app will continue, and apps for mobile shopping, social media, and contents tools are forecasted to further propel capital increase [3].

Smartphone platform competition hinges on how active and invigorated the application market is made to be. Scalability through applications can be said to be the differentiating feature from the standard feature phone, and the smartphone's functions can be expanded to no end [13].

According to Figure 2, as of March 2010 Apple's App Store secured 170,000 applications, and Google's Android market acquired 30,000 applications, making them 1st and 2nd respectively [8].

Figure 1. Sequence of Worldwide App Store Market sales

Figure 2. Number of Apps Available at Smartphones’ App Store

In the midst of fierce competition taking place between App Store and the Android market, the ‘killer app’ has emerged. For the application market to grow, it is important to construct a mechanism of circulation that will allow the spontaneous and continued emergence of killer apps. According to Figure 3 [13], on average, iPhone and Android users downloaded around 8 free applications a month, and used applications for about 80 minutes in a day. 50% of iPhone users download at least 1 paid application a month, and 19% of Android users download at least 1 paid application a month, according to the studies. On average, users download 5 paid applications a month and spend a total of 9 Dollars. This amounts to 1.8 Dollars an app.
Following predictions that the App Store will grow into a service rivaling the web in terms of influence, there has been a gradual rise in the number of firms looking to adopt it effectively for use in their businesses. Content industries are striving to develop mobile apps, and companies are increasingly seeking to improve corporate results in various aspects - business expansion, offering differentiated services, marketing, etc. - with plans incorporating the App Store [8].

Apple's App Store has, in various categories, some 150,000 registered apps, and download numbers reach up to 4.5 billion, but research on what factors compel smartphone users to choose and buy apps has been scarce. The mobile app selling business is expanding rapidly, but the fact is that systematic academic research concerning this field has been inadequate. There has been a dearth of research in analyses of the business aspect of App Store, as compared to research concerning the Apps Store platform or the process of app development.

This study thus aims to analyze through qualitative research the factors that influence smartphone app buying. The implications we can grasp through this research are as follows. First, through the findings on mobile app purpose of buying, work can be done towards development of a new theory. Second, practitioners developing efficient and effective business models for mobile apps may benefit from the findings.

This study will illuminate the factors behind smartphone app buying through the platform of interview. Based on the responses of 30 people, 7 main motives/purposes will be explained. In addition, there will be an analysis of the research results and an illustration of their implications.

### LITERATURE REVIEW

Although at present there is no research on app purpose of buying, there has been plenty of research on the technical aspect of apps like smartphone operating systems, platforms, etc., and many studies on the application of TAM model can be found. Park J.S. [12] is a study on acceptance plans for the open mobile app market, using standard Technology Acceptance Model (TAM) as base for evaluating the effects of amusement, usefulness, flexibility, compatibility, and price on mobile application buying. Kim Y.S. [10] studied factors influencing acceptance of smartphone services by individual smartphone users. Based on TAM and Diffusion of Innovations theory, he researched on whether personal innovativeness, social influence, perceived ease of use, perceived enjoyment, and perceived usefulness, exercised any influence on purpose of smartphone service acceptance. J. Huang and 2 others [5] researched factors influencing smartphone network application performance as users perceived them. They developed a systematic methodology to understand the performance of smartphone application, from the perspectives of the user, developers, network operator, and smartphone retailer. From the results of the analysis, they recommended ways to improve and better application design. Z. Ahmet and L. E. Holmquist [4] presented on mobile service sharing methods between users. They argued that users' downloading habits, new application testing, level of understanding of services under use, etc. exerted influence on service sharing means. Kim H.J. and two others [6] discussed factors that influenced developers' developing intent in the platform business. In the course of in-depth interviews with 7 application developers, 7 types of elements were identified, and a research model based on these findings was used as the platform for the polling. It has been stated that the results of this study can serve as practical guidelines to firms that seek to enter the platform business.

Kim S.H. [9] studied the effects of two added factors, TAM model-controlled variables professional association and experience, on purpose of smartphone acceptance. He proved in his research findings produced with polling methods that professional association and experience were positively affected by mobile wireless technology.


### Table 1. Previous Research

<table>
<thead>
<tr>
<th>Study</th>
<th>Research Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kim Y.S. (2009)</td>
<td>Technology Acceptance Model (TAM) and Diffusion of Innovations theory as platform for research on factors influencing purpose of smartphone service acceptance</td>
</tr>
<tr>
<td>J. Huang et al. (2010)</td>
<td>Study of users’ awareness of factors affecting smartphone network application</td>
</tr>
</tbody>
</table>
RESEARCH METHOD

The worldwide market for Apps Store is expected to grow at an yearly rate of 55–74% from 2011 to 2013. For the same period, applications will grow at a minimum of 54–80%. It is understood that 80% of applications that go up on App Store are paid applications [14].

According to Table2, UK market research firm Ovum [11] claims that the yearly average (2010–2015) growth rate of downloads for paid mobile applications, 48%, will yield approximately 2,500,000 USD downloads in 2015, representing a decrease of 15.4% in its proportion of all mobile application downloads. But the proportion of paid smartphone applications in the entire paid mobile application market is forecasted to grow up to 96% in 2015, up from 78% in 2009. On the back of increasing download revenue as well as paid smartphone applications, all mobile application download revenues are forecasted to show a sustained and stable growth rate.

Table 2. Worldwide Paid Application Download Numbers at Present and Future Prospects

<table>
<thead>
<tr>
<th>(Unit: Million)</th>
<th>‘09</th>
<th>‘10</th>
<th>‘11</th>
<th>‘12</th>
<th>‘13</th>
<th>‘14</th>
<th>‘15</th>
<th>CAGR</th>
</tr>
</thead>
<tbody>
<tr>
<td>smart phone</td>
<td>182</td>
<td>324</td>
<td>831</td>
<td>1,314</td>
<td>1,777</td>
<td>2,258</td>
<td>2,712</td>
<td>52.9%</td>
</tr>
<tr>
<td>non</td>
<td>52</td>
<td>75</td>
<td>90</td>
<td>111</td>
<td>119</td>
<td>126</td>
<td>127</td>
<td>10.9%</td>
</tr>
<tr>
<td>Total</td>
<td>234</td>
<td>400</td>
<td>920</td>
<td>1,424</td>
<td>1,896</td>
<td>2,384</td>
<td>2,839</td>
<td>48.0%</td>
</tr>
</tbody>
</table>

Data Collection

In this study, 30 smartphone users who had experience subscribing to apps were surveyed in an interview format, and data was compiled through their responses. The majority of those who agreed to be interviewed were Apple iPhone users, and the rest were users of Galaxy, Omnia, etc. Interviewees were on average 27.3 years of age, comprising 10 undergraduate students, 9 graduate students, and 11 employed, 18 of them males and 12 females. The average period of smartphone use was 8.39 months. The interview was of a one-on-one format, conducted in an informal environment, ranging from about 10 to 20 minutes. First, the interviewees were asked about the duration of their use of smartphones, the number of apps they bought, and the reasons why they bought them. Then, they were asked whether they had used those apps on a free trial basis at the beginning, and if so, why they later upgraded to a subscribed version. In addition, for those apps that shared the same function, they were asked why they ultimately chose the one they did. Before they proceeded interviewees were sufficiently compensated to ensure they responded truthfully, and their interview responses were recorded instantly.

Table 3. Respondent Characteristics

<table>
<thead>
<tr>
<th>Factor</th>
<th>Class</th>
<th>Sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>Male</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>12</td>
</tr>
<tr>
<td>Age (Average: 27.3yrs)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20s</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>30s</td>
<td>7</td>
</tr>
<tr>
<td>Education</td>
<td>Undergraduate student</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Graduate student</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Employed</td>
<td>11</td>
</tr>
</tbody>
</table>

Average period of smartphone use 3.89 months

Data Analysis

This study employed Strauss and Corbin’s [15] grounded theory method to analyze information from the interviews. Grounded theory method is a qualitative research method, whereby a series of systematic processes extract a single theory out of a phenomenon through inductive method and build on it. Meaning, the main event or problem that the subject regards as meaningful is preserved in their expression and approached from the subject’s point of view. The researcher unearths concepts that are able to explain and interpret the diversity of actions taking place in the domain they wish to study, and form a relationship between these concepts.

In grounded theory method data compilation is mostly accomplished through in-depth interviews, and in this process, the initial discussion begins with everyday conversation, and when trust is established the conversation goes into depth and is continued until all material is exhausted. This method of data assembly has been applied to this study, and its results evaluated through a process called ‘coding’. There are 3 kinds of coding: open, axial, and selective. Open coding is the analysis work that finds, names, and categorizes a phenomenon through review of resources review. This study used open coding to draw concepts explaining purpose of buying for applications. Adopting line-by-line analysis, unusual terms or phrases were looked up and their meanings

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marked on close reading of the materials; and concepts and concepts within the words used by respondents were cited in their original form and named accordingly. Work included giving exact definitions to abstract meanings or concepts, and integrating and rounding up similar concepts into the wider and more generally explainable category mentioned above. The point to this was decreasing the number of the many concepts involved to allow a more focused, macroscopic view on why consumers buy applications. Also, how often the respondents responded to concepts about each purpose of buying application was tallied to make the process of analyzing the relationship between concept and purpose of buying a little easier [15].

DATA ANALYSIS AND RESULTS

Before proceeding to the interview, the authors classified apps into four categories, which were Productivity, Entertainment, Information, and Networking. Then, the authors found out that frequently bought apps were similar according to the classification. The authors classified the related apps according to the standard for the category of classification; the apps were classified as shown in Appendix1. The first category, Productivity, includes business utility apps (e.g., MS file viewer and schedule manager). The second category, Entertainment, includes game, sports, music, and photography apps. The third category, Information, includes finance, news, travel, medical, weather, and other information providing apps. The last category, Networking, includes those apps for the social networking such as Facebook and Twitter.

Based on the interviews, the seven variables that influenced the purchase of smart phone apps were word of mouth, ranking, usefulness, ease of use, trial performance, price, and pleasure. The authors counted the frequency of the seven variables in the four classifications of Productivity, Entertainment, Information, and Networking. Then the authors determined the ranking of the frequency in each classification.

In the type of Productivity, there were several factors affecting the purchase decision in the order of usefulness, word of mouth, trial performance, monetary value, ranking, and ease in use (See Appendix 2). In the type of Entertainment, were several factors affecting the purchase decision in the order of word of mouth, pleasure, ranking, trial performance, monetary value, usefulness, and ease in use (see Appendix 3). In the type of Information, there were several factors affecting the purchase decision in the order of usefulness, word of mouth, monetary value, trial performance, ranking, ease in use, and pleasure (See Appendix 4). In the type of Networking, there were several factors affecting the purchase decision in the order of word of mouth, usefulness, monetary value, ranking, trial performance, pleasure, and ease in use (See Appendix 5).

Figure 4 compares the motivation factors across the four categories. The highest cumulative value was Entertainment, which was 125 times higher, and the Productivity, Information, and Networking followed in descending order. We found out that there were differences among the four classifications for the ranking for purchase intention (see Figure 4).

DISCUSSION ON THE FINDINGS

From the results of the interview about smart phone apps classifying them into four categories, 23 respondents out of 30 purchased apps related to Productivity. 26 respondents were using apps related to Entertainment; 13 respondents were using apps related to Information; and also 13 respondents were using apps related to Networking. Most of the respondents had experience purchasing apps related to Productivity and Entertainment. However, in the case of Networking, there were few respondents who purchased apps that charged money since a domestic free app, ‘Kakao Talk’ was actively used. Apps like a dictionary, which was classified into Information, was not purchased by many people because their prices were relatively higher than other apps.

23 respondents answered that they had purchased apps in the Productivity classification. The highest ranking was useful with 29.7%. Many respondents answered that they had purchased apps because the apps enhanced their efficiency in business and was helpful in their personal lives. The second highest was word of mouth. The answers were recommendations by people, postings that recommended the app as essential in the Internet café and articles in newspaper. In addition, there are many apps, which have the same function as the apps classified in the Productivity group, and the respondents answered that they were influenced by word...
of mouth when they chose one from such apps. That is, they would choose apps, which had good opinions written about them on the Internet café or good reviews in the app store or good recommendations from people. The next were trial performance, monetary value, and ranking. There were answers that indicated they purchased apps because the free version had good functions, the apps had high value for money, and the apps had high ranking in the app market.

Entertainment was used by 26 respondents. The reason that most users purchased Entertainment apps was that the apps were classified into Entertainment; that is, games and the apps of interest were significantly active in the app market, and their prices were relatively inexpensive in many cases. Many of the respondents said that they had purchased the apps because the prices were about 1~3 dollars. First, word of mouth had the highest ranking for purchase intention. The reason may be that such apps were not directly searched for based on necessity but were determined according to others’ opinions in the app store, and the purchase was frequently done by the recommendation of people that the app was fun. The second highest ranking was pleasure. Many respondents that they had purchased the apps since the apps were marvelous; in the case of games, some responded that they had purchased the apps for leisure. The third highest was ranking, which was 15%. Many respondents said that they had purchased the apps of high ranking in the app store when they connected to the app store. The fourth highest was trial performance: it is possible that there are many free versions for trial performance in the case of game apps. Many respondents replied that they purchased apps that charged money because the apps were fun or had limitations in their free versions. The next was monetary value. Particularly in the case of game apps, the respondents seemed to easily purchase apps that they felt were inexpensive. There was a reply on usefulness that the music currently playing could be searched, and a reply on the ease of use whether the handling was simple and easy. Also, some respondents said that he or she purchased the app since he or she originally played the guitar, or he or she had an interest in peculiar and amusing programs.

In total, 13 respondents used Information. Usefulness was the highest ranking; word of mouth, monetary value, trial performance, ease of use, and pleasure followed in descending order. The reason that usefulness was the highest ranking is as follows: apps like dictionaries and navigation are included in the Information classification, and many respondents purchased the apps for convenient use of a necessary function in a smart phone or for study. The second factor that influenced purchase intention was word of mouth, which was 18.3%. The reason that word of mouth had a high ranking is as follows: apps, which belong to the Information classification, have the same function in many cases, and the respondents answered that they were influenced by word of mouth when they choose one of those apps. That is, it is because users received information about good apps through information on the Internet and by reviews in the app store and then compared and analyzed them. Also, many respondents said that they did not purchase the free trial apps but purchased the apps that were recommended by acquaintances or purchased after sufficient consideration of information on the Internet. The third ranking was monetary value. Although dictionaries or books have higher prices than other apps, some responded that they purchased such apps because of good functions and some responded that the purchase of the apps was cheaper than the actual purchase of a real dictionary. Next were trial performance and app ranking.

In total, 13 respondents used Networking. Word of mouth had the highest ranking, which was 41.46%. The respondents answered that they purchased apps that people near them frequently used or recommended. A certain respondent said that he or she changed from a free social network app to an app that charged money because people near he/she frequently used it. The second highest was usefulness, which was 31.7%. Most of the respondents answered that they had purchased the app in order to communicate with friends. Also, some responded that they purchased an app that charged money in order to exchange communication with foreign people. Monetary value was the third highest. This was higher than the response rate of the other classifications; it is possible that the most frequently used app by the respondents, Whatsapp, had the lowest price of all the apps, 0.99$. The next were ranking, trial performance, and pleasure.

The results of the analysis for purchase intention are as follows. Word of mouth was ranked third in the four classifications. This means that the purchase of apps was influenced by the recommendation of others, or by information on the Internet or by reviews in the app store in many cases.

Usefulness ranked in the top or the second place in three of the classifications except for Entertainment. In many cases, people purchased apps for convenience or necessity; in the case of Networking, many people purchased apps in order to communicate with others. In the case of Entertainment, people were not concerned about usefulness but purchased apps because of interest or curiosity. Pleasure was a highly ranked for purchase intention only in the Entertainment group; compared to usefulness, the Entertainment apps were purchased because they were fun, brought about curiosity, or were marvelous.

Trial performance had a higher weight (13.6%) in Entertainment than the other classifications. It is possible that particularly in game apps, there are many free versions that make trial performance possible and during the course of using the free version, people switch to the full version which people pay for. In the case of Networking, trial performance had a low weight (2.44%); it is possible that people trusted an app that many people used without a free trial and they accepted the purchase as essential for communication with others.

Monetary value had generally high rates in the Entertainment and Networking group. In the case of Networking, it was because the price of the app was as inexpensive such as 0.99$, or because the value for the money was high since the app had various functions like free SMS service.

Ease of use was ranked low in most classifications, but it had higher response rates in the Productivity classification, which was 5.94%. There were apps that users had to handle such as a calculator or calendar, and the users seem to prefer the apps with easy usage and simple handling.

Trial performance was remarkably lower in Networking than the other classifications; apps with social network functions do not have activated free versions, and people’s tendencies were to directly purchase an app that most people had used already.
LIMITATIONS

This study reviewed the purchase intention of smart phone apps qualitatively. It has the following limitations. First, the study was confined to the purchase of apps that charged money. Now, free apps are considerably downloaded from app stores and used a lot. Also, during the course of selecting the interviewees, the authors found out that a number of people used free apps only. Therefore, an additional study on the use of free apps seems necessary.

Second, the interviewees were mostly iPhone users. This was because the Apple app store was the most active, and it had abundant number of apps that charged money. Considering now the active mobile app market, the preceding studies should be done on users from various app markets.

Third, the age of the interviewees was mostly in the twenties or thirties. This means that the active users of the app store who purchased apps that charged money were mostly in their twenties or thirties; however, considering that smart phones will be popular in the future, the study ought to reflect the propensity of ages other than the twenties and thirties. This kind of study could generalize the research results by grasping the purchase intention of various ages.

IMPLICATIONS OF THE STUDY

Implications for Research

This study presents the following theoretical and working-level implications. The theoretical implication is to do exploratory research in order to find out the factors which influence the purchase of smart phone apps. Through the results of the exploratory research, the authors extracted variables related to the purchase of mobile apps and confirmed the frequency according to each variable. Since there is no precedent research related to the purchase intention of apps, one possible implication is that the authors clarified the factors related to the purchase intention of apps through their exploratory research since the research will contribute to the methodology and literature study related to purchase intention.

The second theoretical implication is that the authors clarified diverse variables that could influence the purchase of smart phone apps. Among the purchase intentions clarified by this research, there were concepts used in existing marketing research or technology acceptance models such as monetary value, pleasure, usefulness, and ease of use. Also, the variable, 'ranking,' is a newly found variable in this study, and 'trial performance' is also a variable befitting the characteristics of mobile apps. As a result of the exploratory research, the 'word of mouth' variable played a crucial role in the purchase intention of apps; the influence of word of mouth, which is an important factor in marketing, could be proven through the Internet and mobile environments through the research results.

The third theoretical implication is that the authors clarified the difference in the purchase intention of apps according to the four classifications of apps, that is, Productivity, Entertainment, Information, and Networking. The authors counted the frequency of purchase intention according to the four categories and analyzed the results.

Implications for Practice

The working-level implications are as follows. First, the results of this research may suggest the worth that should be considered important when developers develop new apps. If developers who develop apps of diverse use can know customers' purchase intentions of apps within their field of development, they can develop apps of good quality.

The second working-level implication is that the research result can help businesses to plan effective marketing strategies when businesses plan marketing through apps like brand application. In order for customers to download apps from a business and use them continuously, value of the app that can attract customers should be reflected by the app. Value was clarified in this research as trial performance, usefulness, pleasure, and ranking, and monetary value should be reflected by the development of brand applications by businesses.

The third working-level implication is that the research results may contribute to the development of a new business model by companies engaging in the mobile platform business. This research drew out various factors related to the purchase intention of apps when precedent research related to the purchase intention of apps was scarce. The results of this study may be used as a basis on which new business models will be planned and the strategies to activate future mobile app markets can be derived.

CONCLUSIONS

The purpose of this study was to find out the purchase intention for smart phone apps through exploratory research on users who had purchased apps that charged money and to find out the ranking of the purchase intention according to four categories which were classified by the characteristics of the apps. From the results of the exploratory research done in this research, the factors that influence purchase intention were word of mouth, usefulness, ranking, monetary value, trial performance, pleasure, and ease of use. The purchase factors had differences in frequency and ranking according to the classification by the characteristics of the apps, that is, Productivity, Entertainment, Information, and Networking. The authors reviewed the whole ranking of the purchase factors, adding all the categories and analyzed the purchase intention according to the classification. The authors also analyzed the differences in the frequency of the four classifications according to the purchase intention. This study analyzed the implications of the research results and the limitations of the study. It can be pointed out as a limitation of this study that the interviewees were mostly iPhone users and they were all around the same age. However, this study has the following implications. The theoretical implication is that the study discovered results by exploratory research on factors which influenced the purchase of apps while there was no precedent research on the purchase intention of smart phone apps. Moreover, another implication is that the authors classified apps into four classifications and found out the difference in purchase intention according to those classifications. This can contribute to the development of a new theory on the purchase intention of apps and may derive diverse subsequent studies.

The working-level implications are that first, this study may suggest the values of an app that should be considered important when developers develop new apps. Second, this study may help enterprises plan effective marketing strategies when...
enterprises seek to market their products through apps; third, it may contribute to the development of a new business model by companies engaging in the mobile platform business. This study will be the basis on which a study on the purchase of smartphone apps will advance, and it may contribute to the development of a new theory. It may also contribute to the development of an effective business model in the field of mobile apps.

APPENDIX 1: APP CLASSIFICATION

<table>
<thead>
<tr>
<th>Classification</th>
<th>App types in the App Store</th>
<th>Concept</th>
<th>Sort of the apps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productivity</td>
<td>Business Utility Productivity</td>
<td>Apps that amplify business efficiency or that have practicality</td>
<td>MS file viewer, Engineering calculator, Schedule manager, Time table manager, Photo folder organizer, Express bus booking, Scanner</td>
</tr>
<tr>
<td>Entertainment</td>
<td>Game Sports Music Photography</td>
<td>Apps that are interesting and fun.</td>
<td>Game, Face recognition, Mosquito eradicator, Photo decorator, Sleep talking recorder, Tarot card, Playing the guitar</td>
</tr>
<tr>
<td>Networking</td>
<td>Facebook Twitter</td>
<td>Social networking</td>
<td>Whatsapp, TwitBird Pre</td>
</tr>
</tbody>
</table>

APPENDIX 2: DETERMINANTS FOR THE PURCHASE OF PRODUCTIVITY TYPE APPS

<table>
<thead>
<tr>
<th>Productivity</th>
<th>Example</th>
<th>Frequency</th>
<th>Cumulative frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchase intention</td>
<td></td>
<td>Frequency</td>
<td>Cumulative frequency</td>
<td>%</td>
</tr>
<tr>
<td>Usefulness</td>
<td>Many convenient functions, Excellent function, Necessity</td>
<td>30</td>
<td>30</td>
<td>29.70</td>
</tr>
<tr>
<td>Word of mouth</td>
<td>Posting in the Internet cafe, Replies Review in the app store Grade in the app store Recommendation by acquaintance</td>
<td>28</td>
<td>58</td>
<td>27.72</td>
</tr>
<tr>
<td>Trial performance</td>
<td>Free version was good</td>
<td>8</td>
<td>66</td>
<td>7.92</td>
</tr>
<tr>
<td>Monetary value</td>
<td>Proper price, Expensive but the function is very excellent</td>
<td>8</td>
<td>74</td>
<td>7.92</td>
</tr>
<tr>
<td>Ranking</td>
<td>High ranking in the app store</td>
<td>8</td>
<td>82</td>
<td>7.92</td>
</tr>
<tr>
<td>Parameter</td>
<td>Example</td>
<td>Frequency</td>
<td>Cumulative frequency</td>
<td>%</td>
</tr>
<tr>
<td>-----------------</td>
<td>-------------------------------------------------------------------------</td>
<td>-----------</td>
<td>----------------------</td>
<td>-----</td>
</tr>
<tr>
<td>Ease in use</td>
<td>The usage is easy and the installation is easy, The handling is simple, The usage is convenient</td>
<td>6</td>
<td>88</td>
<td>5.94</td>
</tr>
<tr>
<td>Pleasure</td>
<td>marvelous, being curious</td>
<td>3</td>
<td>91</td>
<td>2.97</td>
</tr>
<tr>
<td>Others</td>
<td>Good design, Hated the ad message in the free version The individual early-adaptor propensity</td>
<td>10</td>
<td>101</td>
<td>9.90</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>101</td>
<td>101</td>
<td>100</td>
</tr>
</tbody>
</table>

**APPENDIX 3: DETERMINANTS FOR THE PURCHASE OF ENTERTAINMENT TYPE APPS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Example</th>
<th>Frequency</th>
<th>Cumulative frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word of mouth</td>
<td>Recommendation by acquaintance Information on the Internet Review and grade in the app store</td>
<td>31</td>
<td>31</td>
<td>24.80</td>
</tr>
<tr>
<td>Pleasure</td>
<td>Marvelous Seeming like fun Being curious at reviews For leisure</td>
<td>21</td>
<td>52</td>
<td>16.80</td>
</tr>
<tr>
<td></td>
<td>High ranking in the app store</td>
<td>19</td>
<td>71</td>
<td>15.20</td>
</tr>
<tr>
<td>Trial performance</td>
<td>Because of the limit in the game app stages The free app was fun</td>
<td>17</td>
<td>88</td>
<td>13.60</td>
</tr>
<tr>
<td>Monetary value</td>
<td>The price was inexpensive Expensive but fun</td>
<td>10</td>
<td>98</td>
<td>8.00</td>
</tr>
<tr>
<td>Usefulness</td>
<td>Wanted to know the information of the music</td>
<td>8</td>
<td>106</td>
<td>6.40</td>
</tr>
<tr>
<td>Ease in use</td>
<td>The handling is simple and easy</td>
<td>2</td>
<td>108</td>
<td>1.60</td>
</tr>
<tr>
<td>Others</td>
<td>The payment for the app was convenient Already knew about the app Design Individual interest in playing the guitar</td>
<td>17</td>
<td>125</td>
<td>13.60</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>125</td>
<td>125</td>
<td>100</td>
</tr>
</tbody>
</table>
### APPENDIX 4: DETERMINANTS FOR THE PURCHASE OF INFORMATION TYPE APPS

<table>
<thead>
<tr>
<th>Information</th>
<th>Example</th>
<th>Frequency</th>
<th>Cumulative frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usefulness</td>
<td>For studying foreign language</td>
<td>30</td>
<td>30</td>
<td>42.25</td>
</tr>
<tr>
<td></td>
<td>Seeming convenient for travel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Word of mouth</td>
<td>13</td>
<td>43</td>
<td>18.31</td>
</tr>
<tr>
<td></td>
<td>Recommendation by acquaintance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Information on the Internet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Review in the app store</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grade in the app store</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monetary value</td>
<td>8</td>
<td>51</td>
<td>11.27</td>
</tr>
<tr>
<td></td>
<td>Cheaper than buying books</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Expensive but the function is excellent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Having the term of discount</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Trial performance</td>
<td>5</td>
<td>56</td>
<td>7.04</td>
</tr>
<tr>
<td></td>
<td>The free version does not have many functions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The free version was good</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ranking</td>
<td>5</td>
<td>61</td>
<td>7.04</td>
</tr>
<tr>
<td></td>
<td>High ranking in the app store</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ease in use</td>
<td>2</td>
<td>63</td>
<td>2.82</td>
</tr>
<tr>
<td></td>
<td>Compatible with other programs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pleasure</td>
<td>2</td>
<td>65</td>
<td>2.82</td>
</tr>
<tr>
<td></td>
<td>Marvelous function</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>6</td>
<td>71</td>
<td>8.45</td>
</tr>
<tr>
<td></td>
<td>Good feeling for the brand</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Good service for app administration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Individual preference for speech collections</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>71</td>
<td>71</td>
<td>100</td>
</tr>
</tbody>
</table>

### APPENDIX 5: DETERMINANTS FOR THE PURCHASE OF NETWORKING TYPE APPS

<table>
<thead>
<tr>
<th>Networking</th>
<th>Example</th>
<th>Frequency</th>
<th>Cumulative frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word of mouth</td>
<td>Recommendation by acquaintance</td>
<td>17</td>
<td>17</td>
<td>41.46</td>
</tr>
<tr>
<td></td>
<td>Information on the Internet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Frequent use by people near oneself</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Usefulness</td>
<td>For communicating with friends</td>
<td>13</td>
<td>30</td>
<td>31.71</td>
</tr>
<tr>
<td></td>
<td>In place of international telephone calls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monetary value</td>
<td>The price is inexpensive</td>
<td>7</td>
<td>37</td>
<td>17.07</td>
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<tr>
<td></td>
<td>Having the term of discount</td>
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</tr>
<tr>
<td>Ranking</td>
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<td>2</td>
<td>39</td>
<td>4.88</td>
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<tr>
<td>Trial performance</td>
<td>The functions of the free version is</td>
<td>1</td>
<td>40</td>
<td>2.44</td>
</tr>
<tr>
<td></td>
<td>insufficient</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Pleasure</td>
<td>Wondered</td>
<td>1</td>
<td>41</td>
<td>2.44</td>
</tr>
<tr>
<td>Ease in use</td>
<td></td>
<td>0</td>
<td>41</td>
<td>0.00</td>
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<tr>
<td>Others</td>
<td></td>
<td>0</td>
<td>41</td>
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<tr>
<td>Total</td>
<td></td>
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REFERENCES (BIBLIOGRAPHY)

RESEARCH ON INTERNET-BASED COGNITIVE STYLE

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INTRODUCTION

The study of cognitive style was once an important research topic in the broad field of Management Information Systems (MIS), specifically for Decision Support Systems (DSS) in the 1970s’ and the 1980s’. A great deal of efforts were devoted to study the role of cognitive style in the decision making process assisted by DSS. Cognitive style was regarded as an important factor in the design of DSS to help managers make better decisions. After numerous studies and tremendous research efforts, Huber (1983) published a landmark article arguing against the use of cognitive style as the basis for MIS and DSS design. Several convincing reasons were raised in his paper to explain why the attempt to study cognitive style and use it in MIS/DSS design was not productive. Further study would also be pointless. The article was widely cited and discussed (Robey, 1983). It created a significant impact on subsequent cognitive style research in the fields of MIS and DSS.

NEW REASONS FOR COGNITIVE STYLE RESEARCH

Almost three decades have passed since the publication of Huber’s paper against using cognitive styles as the basis for DSS design. Significant technological changes have happened during this period. The decision making and technology environment today is very different from what it was three decades ago. Several changes may have enabled cognitive style to become a legitimate and viable topic for renewed attention and further research.

First, the wide spread use of technology have changed the decision making and problem solving process. The processes are now more integrated with technology, especially the Internet, according to the Fleshman-Hillard’s Digital Influence Index. Such changes have redefined the meaning of cognitive style. Traditional cognitive style measures may no longer be relevant, and new measures may be needed. The focus now should be on Internet-based cognitive style – how decision makers perceive, think, and remember with the use of the Internet.

Second, decision making assisted by technology is no longer the privilege of business managers. More users are using a wide variety of systems to assist many more decision making and problem solving tasks. In fact, anyone with access to the Internet is able to use some form of DSS to make decisions or solve problems. Consequently, the increased numbers of users and variety of applications have increased the impact of any potential benefit that might come from Internet-based cognitive style research.

Third, technology has enabled the collection of data previously not available. In the 70s’, most data on cognitive style and process could only be collected using self-reported surveys from the decision makers themselves. Now, web sites are constantly tracking user online behaviors, including how they search, pick, process, and store information. Consequently, a large amount of data is available for the study of Internet-based cognitive style and process in the decision-making process.

Fourth, technology also makes it easier to implement the outcomes of cognitive style research. Many web-based applications already can change their user interfaces based on user profiles and preferences. Consequently, integrating user cognitive style into DSS should be possible.

Perceiving with the Internet

A significant change in recent years is the growing reliance on a single channel of information source - the Internet (Kursan & Mihic, 2010; Groves et al., 2010; Lrgan et al., 2010; Wilson et al., 2010; Zhang & Pinkleton, 2009; Hiltunen et al., 2009; Forrest, 2009; Frosch, 2008; Chatzidakis & Mitussis, 2007). The same traditional sources of information are still available. Yet, they might not be used as heavily as before. For many people, the first step to find a solution to any problem often is to search the Internet. For example, students now rarely use the printed resources from the library to solve homework problems. Instead, the great majority of them simply search the Internet for solutions or clues (Megnigbeto, 2006). Printed sources are used, only when the information cannot be located online. The same is true for other types of problem solvers and decision makers. For example, researchers are using online article databases for their studies. Consumers are relying more and more on online reviews to make purchase decisions (Bickart & Schindler, 2001; Byalogorsky, Gerstner, & Libai, 2001). Business managers are using the Internet to check the backgrounds of employees and job applicants (Clark & Roberts, 2010). Furthermore, many people now rely on only a few dominant search engines or portals as the starting point of problem solving and decision making.

To summarize, decision makers or problem solvers are increasingly using the Internet and relying on the same information portals to obtain information. The devices used are also similar. The information they ultimately select could be different; but the methods and processes leading to it are similar. In other words, the perceiving stage of the cognitive process has become more uniformed for many tasks and people. Such standardization could have significant implications on the cognitive process and the way cognitive style is defined.
Thinking with the Internet

The thinking part of the cognitive process is to analyze the information perceived. With the growing number of Internet based applications and pre-processed data, the thinking stage of problem solving or decision making is also different from what it used to be. Take home shopping for example, a potential home buyer in the past typically received a list of homes for sale from a real estate salesperson. Detailed information for each individual home would be printed on separate sheets of paper. Other information, such as neighborhood, shopping, schools, crime rates, and community information would need to be obtained from other sources. In other words, the information was scattered, unorganized, and are in different formats. The home buyer or a good real estate salesperson would have to collect it, integrate it, and process it to help select the right home.

In today’s environment, the home shopping process is quite different. Internet is the first step for many potential home buyers. Numerous web sites provide a large amount of information about homes on the market. Although the basic content might be the same as before, the information is likely to be highly processed, well integrated, logically organized, and methodically formatted to ease the burden of the home buyers. As a result, home buyers no longer need to spend as much time to process the data as they did before. In other words, the thinking stage has been changed or possibly reduced. Home buyers still need to think; but they could focus on different parts of the thinking process. There are numerous other examples of pre-processed information available on the Internet that might have changed the thinking portion of the decision making or problem solving process.

Remembering with the Internet

Information needs to be committed to the memory of decision makers to be used in making decisions. Due to limited memory capacity of decision makers, the decision-making process is often constrained by the availability of information (Simon, 1957).

Technology development in the last three decades has significantly change information availability, which in turn changed the way users remember information (Sanchez & Wiley, 2009). For example, the use of cell phones decreases the needs for memorizing frequently used telephone numbers. The use of GPS systems eliminates the needs to memorize directions and addresses. The use of electronic calendars reduces the needs to remember appointments, meetings, birthdays, and other events. Searchable databases eliminate the needs to remember the location of information. For business decision makers, data warehouses and data mining software reduce the need to memorize important business information for synthesizing and pattern recognition. Besides reducing the need for memorizing information, increased availability also changes the scope of information used for decision making. Decisions makers are no longer constrained by their limited memory capacity. Whatever is available online is what could be used in decision making. Changes in information availability might also affect the cognitive process to some extent. For example, the memory capacity of the decision maker may not be as important as before. Instead, the ability to access and utilize online information resources quickly may be as important as the ability to memorize information. At the same time, the lack of information committed to the memory of decision makers might also change the decision making process.

INCREASED POTENTIAL BENEFITS OF COGNITIVE STYLE RESEARCH

The variety of Internet-based systems that support decision making has significantly increased in the last decade. These systems are no longer limited to assisting structural business decisions using mathematical models. Instead, many systems are available for helping millions of users making a variety of everyday choices. For example, applications are available on the Internet to help consumers make purchase decisions about gifts, cars, homes, insurance policies, and many other products (Häubl & Trifts, 2000). Even for business users, DSS are no longer limited to middle managers. Different systems are available to assist employees performing different levels of tasks. The expansion in the variety of systems and the increased number of users have made the potential impact of any design improvement based on cognitive style greater, and more likely to justify the efforts in research and implementation.

In addition to increased potential impact, the objectives of modern DSS are also different from what it was in the 70s’ and 80s’. One of Huber’s (1983) arguments was that the use of DSS that fit user cognitive style could further reinforce decision makers’ idiosyncratic predispositions. This result was certainly undesirable for traditional DSS. Yet, it might not be so for other types of systems. Many Internet-based systems are not developed purely for the benefits of the users. They are developed by businesses for their customers and potential customers. The purpose is not simply to help users making unbiased decisions; but also to entice users and motivate purchasing. Therefore, re-enforcing users’ cognitive style might be a desirable outcome from the web site’s perspective.

There are existing evidences showing that user cognitive preferences have been considered in the design of web-based systems. For example, many applications and web sites allow users to customize the sizes, layout, options bar, menus, color scheme, and format of data. As Robey (1983) suggested in his responses to Huber (1983), system designers do not need to act like master chefs who assemble all the ingredients to make a productive information system. Instead, system designers only need to provide the ingredients and tools for the users to assemble the ingredients together themselves. Many modern software applications are designed based on this principal. They provide users the flexibility to customize the interface and functions. Technologically savvy users, who are abundant today, are capable of customizing a user interface that meets their own cognitive preferences.
MORE DATA ARE AVAILABLE FOR RESEARCH ON INTERNET-BASED COGNITIVE STYLE

Another significant change for cognitive style research is that more data are available now. In the traditional cognitive style studies, researchers often relied on self-reporting data from the subjects, because the perceiving, thinking, and remembering processes were internal and difficult to observe. When the cognitive processes (perceiving, thinking, and memorizing) are integrated with the Internet, the processes become more explicit. Many steps in the cognitive process could be recorded by the computers in the background unobtrusively. In fact, the collection of data related to user cognitive processes has been performed by web sites for some time. Many companies have been systematically gathering data for just about every aspect of user behavior on the Internet (Malhotra, Kim, & Agarwal, 2004). Researchers could use such data to study Internet-based cognitive styles and their effects on decision making or problem solving, instead of relying on self-reporting questionnaires used in previous studies.

(References available upon request)
An Empirical Study on Commitment Factors for Application Developers & Application Market

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ABSTRACT

In recent years, mobile application market will be expanded rapidly because a smart phone has been diffused in the rapid pace. Mobile application market opened a new market as an intensive and innovative business model in supply. Moreover it changed in consumption mobile phones into market places for mobile applications that have not been experienced in the past. Now that mobile phones are changed the media for communication into the media for smart living that support all of people’s activities. It is an important to get more users for success in app store business but it is more important to get many application developers for developing right applications with right skills. This paper aims to investigate causal relationship within mobile app store maintenance between application developers and application market. In order to achieve our research aim, this paper used application market success factor, dual model, relationship marketing, and e-market place relationship solidarity, conceptual framework to grasp institutional relationship.

Keyword: applications, developers, App Store, applications market, smart phone

1. INTRODUCTION

1.1 Background of Study

Shockwave of the smart-phone market, initiated by iPhone of Apple company, is not ended at the seismic change of the cell phone market, but led to change of communication market, which is expansion of the wireless internet market focusing on data communications, and like PC market, it introduces new competition environment in the whole industry like competitions of OS, search and contents, and creating new ecosystem that is unpredictable [11].

Leading IT companies, incited by the tremendous growth of Apple App Store are opening application markets, and application developers and contents firms are competing to develop mobile application to hit the jackpot. For iPhone users, application market (AppStore) is regarded like a used-to service like voice conversation, and other smart phone users are also being used to usage of AppStore. Likewise, application market (AppStore) is transforming from that for only early adaptors to universal service like Web [23].

Hence, the focus of this research study is to investigate the casual relationship between mobile application market and application developer. Diverse application markets emerge and competition becomes more intense due to shockwave of smart phone market initiated by Apple’s iPhone, and emergence of conditions for growth by changed environment of mobile communication service industry. Therefore, interest on not only the market but also the application developer is growing. Likewise, the reason of growing interest over application market and application developer is threefold.

First, smart phone market is expected to growth rapidly. Among the characters of smart phones, users can install and delete diverse applications, expansion of smart phone market, therefore, can be interpreted as expansion of application market. Secondly, it is expected that open platform market based on 2-sided markets for application sales will grow rapidly. Prospect of application market growth is as follows. According to the Gartner’s recent report, in 2013, total of 15.8 billion applications will be sold worldwide, and an application market with 4.7 billion USD commission fee would be available [23]. Thirdly and lastly, to succeed in application market business, it is important to secure many users, but also important is to secure a number of developers and supplied by high-quality applications for sustainable market [22]. Apple’s AppStore combines app store’s open nature and Apple’s distinctiveness, so application supply is rapidly expanded that tends to hundreds of new applications are registered every day. Through such expansion of supply, customers are able to receive diverse and new applications that they have not experienced before, and from customer’s perspective, it is led to increased attractiveness of Apple AppStore. Increased attractiveness from customer’s perspective in turn resulted in fast increase of application demand, such as influx of new users of AppStore and increased interest of existing users. As a result, developers gained prospect of more profit, and it led to expansion of application supply. As such, a positive cycle of expansion of supply and demand is built, and this is the reason of success of Apple’s App Store [23].

For application market business’ success, utilization of outside assets, in other words external app developers, rather than the company’s internal resource is important. Indeed, to succeed in application market business for companies, it is important to own many users who use the company’s platform, but in the end, the power to attract users and maintain existing users is applications that satisfy their diverse tastes. Only with the company’s ability, there is a limit to develop such applications. Diverse applications developed and supplied by participation of external developers can satisfy diverse taste of application users and this can lead to continued usage of the application market. Therefore, outside developer’s participation (development activities) could be the basis of success of application market business [22]. Although an importance of application market is still growing, research study on application market that is newly emerging from 2008 is lacking. Moreover, some research works are only preparatory ones. There are some documents on success of the service/ technology based on its purpose from user’s perspective. However, there are few research studies from application market supplier’s perspective, and there is a research on platform business vitalization factors for Apple’s iOS based application

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developer [23]. Thus, the importance of this research that studies the factors of causal relationship between application suppliers, developers and application market is our research focus.

1.2. Purpose of Study

Application market provides new opportunity of profit by using Two-side Business Model that creates value by application sales and transaction between developers and customers [31]. Cell phone producers, mobile platform business and communication firms already have perceived an importance of application market within the mobile business value chain, and moving toward into the application market [8].

According to Wikipedia and UCC phenomena, effective usage of external IT and knowledge, while not possessing or controlling everything by the company, could influence the success of business. For success of application market business, as well, it is important to use external assets or that of external developers’, rather than the company’s internal resource, is important. Therefore, sustained and frequent development activities of application development are basis of success of application market [23].

Morgan and Hunt [35] argued that desire and constraint are important factors to form and maintain relationship. The core of this argument is that the reason of maintenance of transaction between A and B, and customer keeps using a certain service provider’s service is ‘have to’ and ‘want to’. The essence and fundamental of relationship marketing is maintenance and development of relationship with customers with absorption and maintenance power that intensify the relationship by starting from interest for individual customer, to making new basis for relationship commitment between customer and company [14].

Trust building between sales participants in electronic transaction is the most important matter in transaction with a party with which transaction experience is lacked. For e-market place, which is similar to application market, trust building causes cooperation among companies, leads open communication, incites adaptation of organization and decreases transaction cost through reduced conflict, and in opposite, the result of lack of trust acts like barriers of overall e-commerce by preventing a number of companies from participation [2]. Therefore, for company to company transaction, understanding the degree of trust on the website and transaction relationship is very important to adopt and promote the e-commerce [32] [42].

Similarly, for core factors for vitalization of application market based on the internet, concept of solidarity of relationship and relational trust between transaction participants and economic satisfaction are raised in this research study. In the previous studies on company to company transaction, it is known that through relationship solidarity real transaction is promoted, as well as cooperation, and long term transaction willingness and inclination for successful relationship are increased. [4] [35]

High solidarity of relationship for certain application market means higher desire to participate in continued transaction in long term perspective and is on the assumption that actual transaction is continued to occur, it is therefore, very important to realize and strengthen the solidarity level between participants of application market and developer. From the current situation, application market business companies (application market service providers like Apple Inc., NOKIA) provide SDK to developers for free, and seem to encourage continued development through reward policies. In other words, the developers who get psychological and material benefit through development and sales of application continue to develop for their sake.

Hence, it is important to investigate the overall factors that influence frequent development of application. Developing application means transaction and relationship with application market service provider, for developers. Therefore, for relationship building and maintenance, many documents argue for importance of study of two sides (dedication and constraint), but since the number of application market that current developers can choose increases and application market is open innovation model, trust building between developers, who are application provider, and market is more important that constraint factors. Application market business companies also seem attracting developers and encouraging continual development, so in this research, following the previous researches, study is to be undertaken by using dual model framework and relationship marketing theory.

Therefore, the purpose of research is threefold: First, it is to clarify causal relationship between diverse independent variables that determine the continued relationship maintenance between application developers and application market and dependent variable and parameter. In order to clarify such independent variable, by accepting research results on application market success factor, dual model, relationship marketing, and e-market place relationship and subtract main variables that influence the actual relationship between application developers and market is suggested and verified. Secondly, as a condition precedent to developer satisfaction, market demand, development frame, usability and influence of alternative attractiveness are deducted based on the previous studies on existing applications’ success factor and verified by positive analysis. Thirdly, as a condition precedent for trust, mutual action and influence of impartiality, suggested by this research are to be verified through positive analysis. Based on previous research on trust, trust building factors suitable for application market situation are deducted, and measurement’s validity is reviewed. Through this, importance for each concept of satisfaction and trust building factors to be provided by application market firms to developers are confirmed, and strategic points to reflect in actual situation are presented.

2. LITERATURE REVIEW

2.1 Success Factors of Application Market

Existing research studies mainly analyze application market’s state and user acceptance of application market, and there is few analysis of application developer and mobile communication companies’ application market. Previous studies on application market’s success factor are

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as shown in table 1.

Table 1 Study on Success Factor of Application Market

<table>
<thead>
<tr>
<th>Researcher</th>
<th>Application Market Success Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yang(2009)[45]</td>
<td>Mobile company’s unique strength (+), development incentive (+), increase of alternative route and dual mode cell phone (+), building ecosystem (+)</td>
</tr>
<tr>
<td>Kim(2009)[22]</td>
<td>Attractiveness of sales profit distribution policy (+), market demand (+), development frame’s usability (+), impartiality of evaluation process (+)</td>
</tr>
<tr>
<td>Ryu Han Seok (2009)[41]</td>
<td>Supply of diverse smart phone devices (+), cheap data communication fee system (+), application ecosystem building (+)</td>
</tr>
<tr>
<td>Lee Sang Don (2009)[28]</td>
<td>Simplified registration process (+), providing clarified profitability (+), using developer network (+), expansion of mass market (+), creating low price level (+)</td>
</tr>
<tr>
<td>Kwon(2009)[26]</td>
<td>Convenient development environment (good SDK), platform influence (+), exiting customers (+)</td>
</tr>
<tr>
<td>Kim(2009)[23]</td>
<td>Innovative device (+), unified development environment (+), wireless connection environment (+), unlimited data payment system (+), SDK (+), application protection (DRM)(+)</td>
</tr>
<tr>
<td>KT Economy Institute (2009)[31]</td>
<td>Motivation and development support system for developers (+), marketing and sales support (+), building store to use diverse terminals (+), improving convenience of users considering UI (+), diversified data fixed fee (+), terminal/OS cooperation (short term)(+), 4 screen based sales, purchase environment (+)</td>
</tr>
<tr>
<td>GDNet Korea (2009)[27]</td>
<td>Color contents (+), cheap price (+), easy development device (+), assured target selection (+), initial customers (+), high function device evolution (+)</td>
</tr>
<tr>
<td>Asia Economic Daily (2009)[9]</td>
<td>Expansion of customers basis through combined app store (+), differentiated contents (+), improvement of UI (including app search)(+)</td>
</tr>
<tr>
<td>ATLAS(2010)[6]</td>
<td>Disclosing mobile company’s own assets (API, etc.) (+), combined payment operator billing (+)</td>
</tr>
</tbody>
</table>

For the success factor study of the application market so far, as in the table 1, it deals mostly with economic perspective and market expansion.

2.2 Dual Model

Social exchange theory provides theoretical basis while analyzing long term relationship building and maintenance process. According to the social exchange theory, people make relationship with others because they want, on one hand, and on the other hand, they do so because of lack of alternative [44]. In other words, there are two mechanisms present in people’s minds. From conceptual perspective, there are two types of commitment for maintenance of relationship. There are dedication commitment and constraint commitment [7]. The former commitment is one that continues relationship by sincerely thinking the relationship as beneficial. In contrast, constraint-based commitment is a commitment to continue relationship reluctantly, because of economic, social and psychological investment as constraint factors.

2.3 Relationship Marketing

The fundamental and core concept of relationship marketing is to maintain and develop relationship with customers and make new basis for relationship promise between customer and company with strong charm and maintenance power that strengthen the relationship with them, starting from interest over individual customer. [14].

In the changing environment, existing marketing has become difficult to play the role to improve competitiveness of company, and importance of relationship with customers is being notices, in order to develop more meaningful relationship with customers for understanding their taste and desire and respond to them. Especially for the service sector, transaction between service provider and customer is not ended in an one-time only transaction but continues through correlation, so the importance of relationship in service industry is getting more.

2.4 Proposed Research Model and Hypothesis Development

From application developer perspective, the factors that influence the solidarity of relationship between application developer and market are classified into satisfaction and trust perspectives based on dual model and literatures on relationship marketing to summarize in Figure 1.

Figure 1 Research Model

If the demand of specific producer to products is expected to be large, wholesalers or retailers buy the relevant producer’s products, because they expect huge profit by selling the producer’s goods. Therefore, producers attempt to prove that their products’ demand is large or could be large [13]. Thus, if developing application for application market that sells the application with developer’s current demand large, it is possible to expect that they would be satisfied with such situation. Thus, the following hypothesis is set.

H1: Application’s market demand would have positive influence on application market satisfaction

Usability has been proven as antecedent variable of the satisfaction in many internet business related researches [1] [24]. In the IS literatures, usability is used as a main standard to measure the user satisfaction of IS [43]. When developing application, development tool is require, and if such necessary development tool is useful, the developer must feel satisfaction to develop the market’s application. Thus, the following hypothesis is set.

H2: Perceived Usefulness of Development kit will have positive influence on application market satisfaction

The alternative’s attractiveness, which could be that of competitor, influences the judgment of customers whether to continue to use the current service provider. While searching for alternative, whether there is alternative or not has meaningful influence on decision making of continued relationship, and if there is an alternative to expect better
outcome than now, the motivation to continue the current relationship is lowered [3]. In addition, if the customers do not recognize that the alternative service provider’s differentiated image or service providing capability is not better than existing providers, the possibility of defection to other alternatives is lowered, and there is a tendency to maintain the relationship with existing providers [3]. Research on attractiveness of alternative can be found in an area that includes individual relationship and employment and transfer rate [16] [40], and in channel relationship [38]. Based on previous research, we can find that from customer’s perspective, compared to the current service provider, as the attractiveness of other service provider is higher, the satisfaction of current service provider is lowered, and based on this, we can set the following hypothesis.

H3: As the attractiveness of alternative is higher, it will have negative influence on application market satisfaction

In marketing area, impartiality is a main variable in company to company relationship [5][15][18][25]. Dwyer et al. [15] argue that impartiality of mutual relationship in sales transaction is critical factor in trust building between two companies, suggesting relationship development model. Anderson and Weitz [5] describes that providers that are rated as having impartiality have more trust and form willingness to continue relationship. Gundlach and Murphy [18] clarifies that as someone realizes that the partner is fair, his/her relationship inclination and satisfaction to the partner increases, and if recognizes the partner as unfair, dissatisfaction increase. When transacting through the Internet, a new technology, by e-Marketplace participants, fairness of transaction process is an important factor that influences the trust, and securing transparency in transaction of online environment will have positive influence on trust. Fairness in transaction process works as positive factor in relationship with partners, and works as an incentive to allow the partner to focus on the joint goal. Therefore, the following hypothesis could be set.

H4: Review Process Fairness recognized by developer will have positive influence on market trust.

Interaction means mutual conversation between participants and a process of communication [39]. Interaction in off-line is limited to human interaction, but for e-commerce, interaction with websites could be done simultaneously, and e-commerce provides on-time communication via computer [19]. Companies, by participating in B2B e-marketplace, participate in actual transaction or gain purchase related information by interacting with managing and participating firms. Therefore, the degree of interaction of B2B e-Marketplace plays important role as an antecedent variable for e-commerce of companies. The degree of interaction in e-Marketplace website solves many problems between transaction partners and allows them to share information. In addition, it reduces incongruity between expectation on partner and realization, providing friendliness and psychological stability, so it strengthens the trust of the relevant website [3][5][15]. Therefore, the following hypothesis could be set for an application market similar to e-Marketplace.

H5: Interaction with market recognized by developer will have positive influence on market trust.

Satisfaction means evaluative judgment caused by relationship benefit. Such satisfaction is recognition of concurrence of expected benefit and actual benefit from the relationship. Such evaluative judgment is in line with dissatisfaction and satisfaction. On the other hand, existing studies discuss the role of trust in relationship from three perspectives; firstly, it is to see satisfaction and trust as a factor that consists relationship quality [10][15]. Secondly, it is to see satisfaction as antecedent factor of trust [17][35], and thirdly, it is to see trust as antecedent variable of satisfaction [3]. Likewise, relationship between trust and satisfaction is argued with different direction of causal relationship, depending on researches, and in this research, following the third perspective, trust is regarded as antecedent variable of satisfaction. The reason is that even if one is satisfied with the service outcome, one may not trust the provider, but it is unlikely to expect service satisfaction from untrustworthy provider. From this perspective, the following hypothesis can be set.

H6: As market trust on developer is higher, it will have positive influence on market satisfaction.

Morgan and Hunt [35] argues that as satisfaction status continues, trust is increased, and by doing so, relationship solidarity increase. In addition, Lee and Gong [29] argues that as service fairness is satisfied, relationship solidarity increases. Jang and Jeong [20] find that recognized service quality, value and fairness have positive influence on customer satisfaction and trust, and as customer has high satisfaction, trust relationship increase. Hence, by considering the result of such preceding studies, in this study, the hypothesis of relationship between market satisfaction and relationship solidarity is set as follows.

H7: As satisfaction rate on developer is higher, it will have positive influence on intention to continue relationship with the market.

Dwyer [15] argues that if both parties trust each other, they can solve difficult problems like power, conflict and low profit, so because of the role of trust, trust leads the highest level of relationship transaction, solidarity. Morgan and Hunt [35] argue that relationship characterized by trust is valued, so it plays important role in relationship transaction. In addition, solidarity is followed by variability, so transaction parties will seek trusted partners, and trust plays important role of decision making in relationship solidarity. Ganesan [17] analyzes the effects of mutual dependence and trust as decisive factor of long-term orientation between purchaser and seller. They analyze the effect of trust-forming factors, which are credibility and good will, and their effect on trust, and as a result of analysis, veracity has influence on trust, but good will does not. Mooman [33] verifies that trust of marketing research users have meaningful influence on solidarity of the users on the survey result.

H8: As market trust on developer is higher, it will have
positive influence on relationship continuance intention with market.

3. RESEARCH METHODS

3.1 Design
In this research, ‘Market Demand’, ‘Perceived Usefulness of Development Tool’, and Alternative Attractiveness will be selected as independent variables of economic side. For intermediary variable, ‘satisfaction’ will be selected, and for dependent variable will be expected that satisfaction has influence, commitment will be selected. For independent variable from relationship perspective, ‘Review Process Fairness’ and ‘interactivity’ will be selected. For the influenced intermediary variable, trust will be selected, and for dependent variable that will be expected to influence the trust, commitment will be selected. Based on the used measurement items derived from related literature studies and each variable’s operating definition, three to four items will be measured as shown in Table 2.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Operational Definition</th>
<th>Item</th>
<th>Researcher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market Demand</td>
<td>Level of application demand on sale in application market</td>
<td>1.1 In [A market] demand of users on diverse application is large</td>
<td>[21]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2 In [A market] many people download applications.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.3 In [A market] demand for application is growing rapidly.</td>
<td></td>
</tr>
<tr>
<td>Perceived Usefulness of Development Tool</td>
<td>Degree of usability of development frame supplied by application market.</td>
<td>2.1 SDK supplied by [A market] is effective to make application with functions desired by me (our company)</td>
<td>[12]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.2 SDK provided by [A market] increases the productivity of the work that produces application with my desirable function</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.3 SDK supplied by [A market] increases the work outcome that produces application with desirable function of me (our company)</td>
<td></td>
</tr>
<tr>
<td>Alternative attractiveness</td>
<td>Degree of attractiveness on other application market</td>
<td>3.1 Other application market’s profit distribution policy is more attractive than [A market].</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.2 Other application market provides more desirable service than [A market] for me (our company)</td>
<td>[36]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.3 Other application market is easier to sell application than [A market]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.4 Other application market is more satisfactory than [A market]</td>
<td></td>
</tr>
<tr>
<td>Review Process Fairness</td>
<td>Degree of fairness of application review process</td>
<td>5.1 [A market]’s application review process is fast.</td>
<td>[25]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.2 [A market]’s application review process is objective.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.3 [A market]’s application review process is fair.</td>
<td></td>
</tr>
<tr>
<td>Interactivity</td>
<td>Easy communication with application developer</td>
<td>4.1 [A market]’s communication with me (our company) is active.</td>
<td>[3]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.2 [A market] reflects my (our company) opinion actively.</td>
<td>[19]</td>
</tr>
</tbody>
</table>

3.2 Data Collection Method and Characteristics of Samples
The purpose of this study is to find the factors that influence the relationship solidarity between application market and developer, basis of success factors of application market, so the research objective can be developer who are developing or have developed common OS-based smart phone application or who understand it.

Questions will be measured by 7 point Likert scale, and from operational definition of this research, the scales that are proved of validity in previous studies will be used. For data collection, online and offline method will be simultaneously used, and online method will be used by Google’s web survey, and for offline, data will be collected from developer conference, developer center, partner companies and friends.

4. CONCLUSION
Solidarity of relationship can be viewed as application transaction with market and continued development of application by application developers. In this research, considering this point, for variable to measure the success of application market, relationship solidarity between application developer and market is selected, and the relationship between them will be verified empirically, by clarifying the necessary factors of relationship solidarity. As application market is diversified and competition got intense, there will be a situation in which one must select a market to transact continually, among many application markets. The standard in this regard shall be diverse and useful application. There is a limit for application market firms’ ability to secure such application. Through applications developed and supplied by a number of developers, various demands of users can be satisfied, and this can be connected to continued market usage by smart phone users. Therefore, participation of external developers (development activities) can be a basis of application market.
business success [22]. On the other hand, while not only terminal platform firms which realized the importance of securing developers, but also application market like terminal producers and mobile firms are trying to attract developers through diverse support policies like development education, supply of development frame and conference, but there is no practical outcome, as expected.

In this research, success of application market will be interpreted as continuation of relationship between application developer and market, and satisfaction in terms of profit side and trust in terms of relationship side are separately identified. Especially, it will be meaningful that the relationship marketing theory, which is mainly applied to marketing area, will be applied to application market, a typical 2-sided market. In addition, there will be a practical meaning since it will clarify main variables that can result in successful application market business. Relevant personnel can lead each result activities by using the factors to meet the need. If the independent variables stipulated in this research are used effectively, success in application market will be closer. Since there are few research in importance of solidarity of relationship between application developer and market, the research is expected to be a huge help for application market business personnel. In previous research studies, the focus has been mostly application market status or application purchaser side. This research will fill the research gap with necessity of developer (seller) perspective, which is few, so it will provide more mutual understanding on social phenomenon of managing application market.

5. REFERENCES

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[6] ATLAS, “Securing distinction is the most important thing,”, 2010
APPLICATION OF ROUGH SETS TO PATIENT SATISFACTION ANALYSIS

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ABSTRACT

Patient satisfaction survey has been widely used by healthcare providers to gauge their service level and initiate process improvement actions. Usually, summary statistics from the survey results such as means, percentile ranks, and correlation coefficients are analyzed for operational decisions. This paper presents a rough set approach to analyze patient satisfaction survey data collected from a medium-sized community hospital in USA. Advantages of this approach lie in its ability to process data with vagueness and uncertainty, data reduction capability, and strong interpretation ability of decision rules, which can be used to build rule-based inference systems.

Keywords Patient satisfaction survey analysis, rough set theory, data reduction, decision rules

INTRODUCTION

Hospitals are facing tremendous challenges to make the healthcare delivery system safe, effective, patient-centered, timely, efficient, and equitable. In pursuit of operational excellence, patient satisfaction survey has been widely used by the hospitals to measure their service levels during the course of healthcare delivery. According to the U.S. Department of Health and Human Services [1], these surveys are designed to provide hospitals with the information and insight on their service levels from patients perspectives. Investigation of survey responses will assist hospitals to detect weakness in their services, develop strategies for service quality improvement, track service quality improvement over time, and compare their services with other competitors as well. There have been companies that provide exclusive service for patient satisfaction survey analysis. Representative of them is the notable Press Ganey Associates Corporate [2], which designs a set of standard survey questions for its customers (i.e., hospitals). The Press Ganey survey measures patients’ perception of how well their experiences with a certain hospital were, using a rating scale of Very Good, Good, Fair, Poor, and Very Poor. The survey is composed of several sections with each section consisting of several questions to measure a specific aspect of the patient care received, such as patient care related to admission, room, nurses, physicians, etc. Patients rate their satisfaction level in each section. They also rate their perception with the overall care the hospital provides, as well as their likelihood to recommend this hospital to others.

Commonly, after the completed surveys are collected, survey responses are analyzed. Note that before conducting analyses, the responses need to be transformed into being of numerical form if the original rating scale is non-numerical. For example, the rating scale in the Press Ganey survey questionnaire can be transformed into \{5, 4, 3, 2, 1\}, with 5 standing for ‘Very Good’, 4 standing for ‘Good’, etc. The commonly used analysis methods for patient satisfaction survey include calculating means, standard deviations, correlation coefficients, percentile ranks, and so on. While correlation coefficient investigates the relationship between two survey questions, other analyses like mean and standard deviation look into a specific survey question only. For instance, percentile ranking tells a hospital of which percentile its score is compared with other hospitals with similar settings for the corresponding survey question. Obviously, the higher the percentile, the better the service of the concerned hospital compared to others. This method well demonstrates the competitiveness of a hospital.

In this paper, an approach using rough set theory is proposed for a more advanced analysis of patient satisfaction survey data. The rough set theory, introduced by Pawlak [3], has been proved to be an effective tool for handling the data with uncertainty or vagueness [4, 5]. This theory is of fundamental importance in artificial intelligence and cognitive sciences, especially in such research areas as machine learning, intelligent systems, inductive reasoning, pattern recognition, knowledge discovery, and expert systems [4]. The rough set approach has been applied in many fields, including bioinformatics [6, 7], medicine [8-10], business failure prediction [11, 12], computer network systems [13], business aviation decision making [14], acoustics [15], and other domains [16, 17]. For more applications, the readers are referred to [4, 18, 19]. In this paper, the rough set approach was used to reduce data dimensionality, i.e., to remove redundant survey questions and identify key survey questions that influence patient satisfaction, and to induce rules for investigating the methods to improve patients’ overall satisfaction with the service/care a hospital provides.

The remainder of the paper is organized as follows. Section 2 presents the basic knowledge of the rough set theory. Section 3 describes the survey questionnaire under study and the preliminary handling of the collected responses. Section 4 analyzes the survey data using rough sets and interprets the derived rules. Concluding remarks are included in Section 5.

BASICS OF THE ROUGH SET THEORY

Pawlak [3] introduced the rough set theory, which is a mathematical approach to tackling imperfect data (e.g., data with uncertainty or incompleteness). This approach is complementary to other uncertainty data handling methods such as probability theory, Dempster-Shafer theory of evidence, fuzzy set theory, and so on. The main advantage of the rough set theory lies in that it does not need any preliminary information about data like probability distributions in statistics, basic probability assignments in Dempster-Shafer theory, a grade of membership or the value of possibility in fuzzy set theory [4, 20-22]. Other
advantages of the rough set approach can be found in [11, 23, 24].

Information Systems

An information system is defined as a 4-tuple \( S = (U, Q, V, f) \), where \( U \) is a finite set of objects, \( Q \) is a finite set of attributes, \( V \cup_{q \in Q} V_q \) is a set of possible attribute values with \( V_q \) being the domain of the attribute \( q \), and \( f : U \times Q \rightarrow V \) is a function such that \( f(x, q) \subseteq V_q \) for every \( x \in U, q \in Q \).

The mathematical basis of the rough set theory is indiscernibility relation. Let \( B \subseteq Q \) and \( x, y \in U \), \( x \) and \( y \) are indiscernible with respect to \( B \) if and only if \( f(x, q) = f(y, q) \) for every \( q \in B \). Given a certain \( B \subseteq Q \), a set of indiscernible objects comprise an equivalence class. Obviously, different \( B \subseteq Q \) has different equivalence classes. Equivalence classes of \( B \) are also called \( B \)-elementary sets. We denote by \( I_B(x) \) a \( B \)-elementary set that contains the object \( x \in U \).

Approximations and Quality of Classification

Lower approximation and upper approximation are two basic operations in rough set theory. Let \( B \subseteq Q \) and \( X \subseteq U \). The \( B \)-lower approximation and \( B \)-upper approximation of \( X \), denoted by \( \underline{B}(X) \) and \( \overline{B}(X) \), respectively, are defined as follows:

\[
\underline{B}(X) = \{x \in U : I_B(x) \subseteq X\},
\]

\[
\overline{B}(X) = \{x \in U : I_B(x) \cap X \neq \emptyset\}.
\]

The difference between two approximations is defined as the \( B \)-boundary region of \( X \), which is denoted by \( B N_B(X) \) and calculated by the following equation:

\[
B N_B(X) = \overline{B}(X) \setminus \underline{B}(X).
\]

\( B(X) \) is a set of objects that can be certainly classified as the elements of \( X \) in terms of the set of attribute \( B \). \( \overline{B}(X) \) is a set of objects that can be possibly classified as the elements of \( X \) in terms of \( B \), and \( B N_B(X) \) is a set of objects that cannot be certainly classified to \( X \).

If \( B N_B(X) \neq \emptyset \), i.e., \( B(X) \not\subseteq \overline{B}(X) \), the set \( X \) is said to be crisp or exact with respect to \( B \). On the other hand, if \( B N_B(X) = \emptyset \), then the set \( X \) is referred to as rough or inexact with respect to \( B \). That is, a rough set, in contrast to a crisp set, has a non-empty boundary region. Any rough set is associated with the accuracy of approximation by \( B \), which is defined as

\[
\alpha_B(X) = \frac{\text{card}(\overline{B}(X) \setminus \underline{B}(X))}{\text{card}(\overline{B}(X))},
\]

where \( \text{card}(\cdot) \) denotes the cardinality of a set. Clearly, \( 0 \leq \alpha_B(X) \leq 1 \). If \( \alpha_B(X) = 1 \), then \( X \) is crisp with respect to \( B \).

Another important concept in rough set theory is the quality of approximation of classification, or in short, quality of classification. Let \( Y = \{Y_1, Y_2, \ldots, Y_k\} \) be a mutually exclusive classification (or partition) of the universe \( U \). The quality of classification, denoted by \( \gamma_B(Y) \), is defined as below:

\[
\gamma_B(Y) = \frac{\sum_{i=1}^{k} \text{card}(\overline{B}(X_i))}{\text{card}(\overline{B}(X))}.
\]

It expresses the ratio of all \( B \)-correctly classified objects to all objects in the system. If \( \gamma_B(Y) = 1 \), then the classification \( Y \) is crisp (or precise) with respect to the set of attributes \( B \).

Reduct and Core

One of the most important contributions of rough set theory to the data analysis field is that it can remove superfluous information. The involved concepts are reduct and core. A reduct \( R \subseteq Q \) of an information system \( S \) is defined as a minimal subset of attributes that preserves the quality of classification as the set of all attributes \( Q \). That is, \( \gamma_S(Y) = \gamma_R(Y) \). Usually, there exist more than one reduct for an information system. The intersection of all reducts is called a core. The core is therefore the most important subset of attributes, since none of its elements can be removed without affecting the classification power of attributes.

Decision Rules

Sometimes the set of attributes \( Q \) can be divided into two mutually exclusive sets \( C \) and \( D \) (i.e., \( Q = C \cup D, C \cap D = \emptyset \)), with \( C \) containing condition attributes and \( D \) containing decision attributes. Such an information system \( S = (U, C \cup D, V, f) \) is also called a decision system. A set of decision rules can be derived from a decision system.

A decision rule is any expression of the form \( \Phi \Rightarrow \Psi \), which reads that if \( \Phi \) holds, then \( \Psi \) holds. \( \Phi \) is a conjunction of elementary condition formulae, i.e., \( \bigwedge \{a_1 \land \ldots \land a_n \} \), while \( \Psi \) is a disjunction of elementary decision formulae, i.e.,
\( \{ d, k_1 \} \cdots \{ d, k_\tau \} \). If \( \tau = 1 \), the decision rule is exact. Otherwise, it is approximate. An approximate rule means that, using the available knowledge, some objects cannot be definitely assigned to a decision class. An important characteristic of a decision rule is its support, which is defined as the number of the objects that obey this rule. Several procedures have been proposed [25-28] for inducing decision rules from a decision system.

**Decision Support or Classification**

The derived decision rules can be used for decision support of a new object (i.e., classifying a new object into a decision class). Specifically, this is done by matching the description (or the condition attribute values) of the new object to one of the decision rules. Accordingly, there are four possible situations [29, 30]:

1. If the new object matches a single exact rule, then the new object is classified into the decision class pointed by the rule.
2. If the new object matches more than one exact rule that indicate, however, the same decision class, then the object is assigned to that decision class.
3. If the new object matches one approximate rule or several exact rules that indicate different decision classes, then the object is classified into the decision class which has the largest support.
4. If the new object does not match any of the rules, then the object is assigned to a decision class by the nearest rule, i.e., nearest according to the selected distance metric (the \( L_p \)-metric or valued closeness relation [29]). If there are several rules with the minimal distance to the object, then the object is assigned to the class with the largest support.

**DESCRIPTION OF PATIENT SATISFACTION SURVEY DATA**

The concerned patient satisfaction survey was conducted in a community hospital in the United States. The survey population are the inpatients who were discharged during the period from October 2008 to September 2009. Press Ganey survey questionnaires were used, including 37 standard questions which are listed in Appendix. These questions cover 10 sections: admission section (a), room section (r), food section (m), nurse section (n), test section (t), visitor section (v), physician section (p), discharge section (d), staff section (i), and overall care section (o). The rating scale for these questions is \{ Very Good, Good, Fair, Poor, and Very Poor \}. For the convenience of analysis, this scale is converted into a numerical form \( \{ 5, 4, 3, 2, 1 \} \), with 5 standing for ‘Very Good’, 4 standing for ‘Good’, etc.

The hospital received 815 responses totally, among which 507 responses answered all 37 standard questions. These 507 survey responses comprise the information system under study. For simplification, the responses for the 3 questions in the overall care section are averaged, and the rounded average is taken as a single decision attribute which is denoted by the label ‘AvgO’. The other 34 questions are considered to be condition attributes. Among the 507 complete responses, the number and percentage of the responses that have a given value of ‘AvgO’ are shown in Table 1.

<table>
<thead>
<tr>
<th>AvgO</th>
<th>Number of Responses</th>
<th>Percentage of Responses (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>1.18</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>0.99</td>
</tr>
<tr>
<td>3</td>
<td>21</td>
<td>4.14</td>
</tr>
<tr>
<td>4</td>
<td>103</td>
<td>20.32</td>
</tr>
<tr>
<td>5</td>
<td>372</td>
<td>73.37</td>
</tr>
</tbody>
</table>

The significant differences among the numbers of the responses for these 5 satisfaction levels make it difficult to conduct accurate classification analysis of patient satisfaction survey. Therefore, combined with the consideration of the structure of the responses for ‘AvgO’, the following transformation is implemented on the information system: the satisfaction levels \( \{ 1, 2, 3 \} \) are regarded as a single level and denoted by ‘3’. In other words, the entries of \( \{ 1, 2 \} \) in the investigated information system are changed into ‘3’. Thus, the adjusted information system includes 3 levels only, representing ‘Not Good’, ‘Good’, and ‘Very Good’, respectively. As Table 1 indicates that most patients were very satisfied with the service/care they received in this hospital, the analysis of the transformed information system is expected to lead to the following results: (1) to discover what aspects of the service the patients considered the most unacceptable so that they gave the average overall satisfaction score of ‘3’; (2) to explore what aspects of the service can be improved so that the average overall satisfaction score can change from ‘4’ to ‘5’; (3) to find out what aspects of the service are critical for the hospital to receive a score of ‘5’ on its overall service/care.

**SURVEY ANALYSIS AND RESULTS**

The rough set analysis was conducted on the transformed information system, and was performed using the software ROSE2 which was created at the Laboratory of Intelligent Decision Support Systems of the Institute of Computing Science in Poznan [30]. The analysis of the transformed information system shows the following results:

1. With respect to the set of all condition attributes (i.e., 34 standard questions in the sections other than the overall care section), the approximation of each decision class is perfect. In other words, \( \mathcal{Z}_Q(\mathcal{Y}_i) \) \( \subseteq \{ 1, 2, 3 \} \), where \( Q \) is the set of all condition attributes and \( \mathcal{Y}_i(1, 2, 3) \) denotes each decision class, with the value of ‘AvgO’ being 3, 4, and 5, respectively. Besides, the quality of classification is perfect as well, namely, \( \mathcal{Y}_Q(\mathcal{Y}) \) \( \subseteq \), where \( \mathcal{Y} \) \( \{ \mathcal{Y}_1, \mathcal{Y}_2, \mathcal{Y}_3 \} \) is the
classification of all 507 responses based on the value of the decision attribute of ‘AvgO’. The perfect approximation of each decision class and the perfect quality of classification imply that all responses in the information system (patient satisfaction survey results) can be clearly distinguished into each decision class, i.e., the classes of ‘Not Good’, ‘Good’, and ‘Very Good’.

(2) The core of the attributes is empty. According to the definition of core in Section 2.3, this means that no single attribute is absolutely necessary for the perfect approximation of each decision class and the perfect quality of classification. If there is a non-empty core, then the attributes contained in the core are the most important and indispensable attributes for preserving the quality of classification. This implies among the 34 survey questions, not a single survey question can be identified as the most significant question affecting patient overall satisfaction.

(3) There are a considerable number of reducts derived from the information system under study. This is due to the relatively large number of condition attributes (i.e., 34) and the significant unbalance among the decision classes. As far as the shortest reducts are concerned, there are totally 138 such reducts, with each including 9 attributes. Based on the selection criteria adopted in [11, 14], the most significant attributes from the perspective of the decision makers (the hospital managers) are included and the number of attributes are kept as small as possible. The following reduct was selected for further analysis: {a1 (Speed of admission), r2 (Room cleanliness), r4 (Room temperature), r5 (Noise level in and around room), m3 (Quality of the food), n2 (Promptness response to call), t5 (Courtesy of person took blood), p5 (Skill of physician), d2 (Speed of discharge process)}. This dramatically reduces the size of the information system, while keeping the quality of classification according to the definition of a reduct. In other words, the above 9 survey questions are identified as the most significant questions that impact the patient satisfaction rating.

The next step is to study how the different combinations of the responses to the 9 survey questions lead to different patient overall satisfaction ratings, based upon which a set of “decision rules” will be generalized. This is essentially useful for hospital managers to quantitatively decide what aspects of the care delivery process need to be improved. Reserving the 9 attributes in the selected reduct and removing the other 25 attributes from the information system result in a reduced information table, from which a set of decision rules will be derived. A rule induction algorithm LEM2 (Learning from Examples Module, Version 2) [25] was used to generate a minimal set of rules covering all objects in the reduced information system.

There are a total of 99 rules derived. Table 2 shows part of the rules for each decision class. For the decision class of AvgO 3, only the rules with support greater than or equal to 5 are considered. For the other two decision classes, the requirements of support greater than or equal to 7 and support greater than or equal to 10 are executed, respectively. Such actions are based on the consideration of different numbers of responses in the decision classes. Other rules that do not satisfy the above support requirements are regarded too weak to take into account. The rules in the tables are easy to understand. Take Rule 1 in Table 2 as an example. It means that, if a patient rates r2 (Room cleanliness) as “Not good”, and p5 (Skill of physician) as “Not good”, then the patient’s overall satisfaction rating is “Not good”, regardless of the patient’s other ratings to other questions. Moreover, there are 8 survey responses supporting this rule. The shorter a rule, the stronger it is. Also, the larger the support of a rule, the stronger the rule. The accuracy rate of the derived decision rules is also evaluated. The average classification accuracy rate is 81.07%, based on 10 times of 10-fold cross validation.

Table 2 The decision rules for the decision class of AvgO = 3, with support >= 5

<table>
<thead>
<tr>
<th>Rule #</th>
<th>a</th>
<th>r1</th>
<th>r2</th>
<th>r4</th>
<th>r5</th>
<th>m3</th>
<th>n2</th>
<th>t5</th>
<th>p5</th>
<th>d2</th>
<th>AvgO</th>
<th>Sup</th>
</tr>
</thead>
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<tr>
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<td>1</td>
<td>3</td>
<td>2</td>
<td>4</td>
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<td>5</td>
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<td>1</td>
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<td>3</td>
<td>3</td>
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<td>3</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 2 contains the decision rules for the decision class of AvgO 3 with support >= 5. Rule #1 in Table 2, as discussed above, is a strong rule, since its length is only 2. It reflects that, the hospital should pay attention to these two questions r2 (room cleanliness) and p5 (skill of physician), because that if both aspects are dissatisfying (i.e., patients rate them ‘Not Good’), the hospital will receive a dissatisfactory rating about its overall service/care. Besides, it is found from Table 2 that r2 3 (room cleanliness rated as “Not good”) appears three times in the above 4 rules. This implies that, if a patient is not satisfied with room cleanliness, then the chance of the hospital receiving a dissatisfactory overall rating is high. Therefore, the hospital should try to improve r2’s rating (i.e., make rooms clean to make patients comfortable and happy). Similarly, since r2 (nurses’ promptness of response to call), p5 (skill of physician), and d2 (speed of discharge process) receive low scores twice in the above rules, they should also be noted. In Rule #4 in Table 2, 3 4 (“Noise level in and around room” rated as “Good”), however, the overall rating is still not good (i.e., AvgO)`.

Table 3 The decision rules for the decision class of AvgO = 4, with support >= 7

<table>
<thead>
<tr>
<th>Rule #</th>
<th>a</th>
<th>r1</th>
<th>r2</th>
<th>r4</th>
<th>r5</th>
<th>m3</th>
<th>n2</th>
<th>t5</th>
<th>p5</th>
<th>d2</th>
<th>AvgO</th>
<th>Sup</th>
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<td>4</td>
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<td>2</td>
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<td>7</td>
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</tbody>
</table>
Table 3 shows the decision rules for the decision class of $\text{AvgO} = 4$ with support $\geq 7$. It can be seen from this table that, $\text{AvgO} = 4$ when the number of the survey questions whose score is 4 is larger than or equal to 4. It makes sense since the overall rating is based on the perception of patients on each aspect of the service. It is also observed that, in all rules of Table 3, the following questions have higher frequency of receiving a rating of ‘Good’ (i.e., $\text{AvgO} = 4$): $r_5$ (noise level in and around room), $m_3$ (quality of the food), $p_5$ (skill of physician), and $d_2$ (speed of discharge process). This demonstrates that, these questions are critical for the hospital to achieve a good rating of its overall service/care. Paying more attention to these aspects may make patients more satisfied and lead to a better overall rating. In Rules #4 and #5, $n_2 \geq 3$, however, the hospital still receives an overall rating of ‘Good’. Since $n_2$ denotes the nurses’ promptness of response to call, this may reflect that, the response of the nurses to call is not quick and this aspect should be emphasized and improved. It also means that, bad performance of few aspects does not influence the overall rating too much, if other aspects perform well. The patients have tolerance for some aspects. On the other hand, $a_1 \geq 5$ in Rules #6 and #7. It shows the opposite. In other words, good performance of few aspects does not have a big impact the overall rating.

Table 4 is a set of decision rules for the decision class of $\text{AvgO} = 5$ with support $\geq 10$. Rules #1 and #4 are strong rules with the length of 2 and big support. They explore that, $r_4$ (room temperature) and $n_2$ (nurses’ promptness of response to call) (or $r_3$ (noise level in and around room)) are significant survey questions for patients to think of the overall service/care of the hospital ‘Very Good’. This is because that, if both $r_4$ and $n_2$ (likewise, $r_4$ and $r_3$) score 5, then the hospital receives an overall rating of ‘Very Good’. It may also indicate that, $r_4$ and $n_2$ (likewise, $r_4$ and $r_3$) are the aspects that usually perform worse than the other aspects do, therefore, if they are greatly improved to make patients very satisfactory, then the overall rating can reach ‘5’. Thus, if the hospital wants to have a ‘Very Good’ overall service/care, it should pay attention to $r_4$ and $n_2$ (likewise, $r_4$ and $r_3$). Furthermore, in all rules in Table 4, the frequency of $r_4$ = 4 and that of $r_3$ = 4 are high. This further verifies that, $r_4$ and $r_3$ are the aspects that have worse performance compared with other aspects in this class. Although patients give an overall rating of ‘Very Good’, they are apparently tolerating with these two aspects. Therefore, the hospital should start to come up with ideas to improve the service in these two aspects. In addition, the other aspects that need special notice include $r_2$ (room cleanliness), $p_5$ (skill of physician), and $d_2$ (speed of discharge process), since their occurrence rates in Table 4 are high. In order to receive a highest score for its overall service/care, the hospital ought to make the performance of these aspects outstanding. This is because that the chance of achieving a ‘Very Good’ overall service greatly increases if these aspects perform very well.

In sum, to avoid having a bad overall rating of ‘3’, the hospital should pay close attention to the following aspects: $r_2$ (room cleanliness), $n_2$ (nurses’ promptness of response to call), $p_5$ (skill of physician), and $d_2$ (speed of discharge process). For receiving a good rating of its overall service/care, the following aspects should be highly concerned: $r_3$ (noise level in and around room), $m_3$ (quality of the food), $n_2$ (nurses’ promptness of response to call), $p_5$ (skill of physician), and $d_2$ (speed of discharge process). Lastly, for achieving a very good overall rating, the hospital needs to make sure of very good performance of the following aspects: $r_2$ (room cleanliness), $r_4$ (room temperature), $r_3$ (noise level in and around room), $n_2$ (nurses’ promptness of response to call), $p_5$ (skill of physician), and $d_2$ (speed of discharge process). It is noticed that, $n_2$ (nurses’ promptness of response to call), $p_5$ (skill of physician), and $d_2$ (speed of discharge process) all appear in the above three suggestions. It implies that, these three aspects are very critical and the hospital should try to make the performance of these aspects very good. Moreover, it is noted that, $a_1$ (speed of admission) and $r_5$ (courtesy of person took blood) do not appear in the above three suggestions. This indicates that, these two aspects do not have big influences on the overall rating of the hospital.
CONCLUDING REMARKS

Patients’ satisfaction is a very important measure of the care/service provided by hospitals. Almost every hospital in the United States conducts patient satisfaction survey to evaluate their service performance. Common statistical approaches, such as percentile ranks, correlation analysis, have been used to analyze survey data for hospital operational decisions. In this paper, a novel approach using the rough set theory was studied to analyze the patient satisfaction survey data obtained from a community hospital in USA. The rough set approach has many advantages over other approaches, especially in its ability of dealing with vague data, reducing data size, and inducing a set of decision rules that are easy to interpret. In this paper, 9 out of 34 survey questions are first identified as the most significant questions that influence patient overall satisfaction ratings. A set of useful decision rules are then derived to provide the hospital with some insightful suggestions on how to improve its service. Specifically, the aspects of the service that need to be paid close attention to are pointed out. Overall, the rough set approach is proven to be a useful tool for the analysis of patient satisfaction survey.

Appendix

Explanations to Standard Questions in Press Ganey Patient Satisfaction Survey

<table>
<thead>
<tr>
<th>Question</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>a1</td>
<td>Speed of admission</td>
</tr>
<tr>
<td>a2</td>
<td>Courtesy of person admitting</td>
</tr>
<tr>
<td>r1</td>
<td>Pleasantness of room decor</td>
</tr>
<tr>
<td>r2</td>
<td>Room cleanliness</td>
</tr>
<tr>
<td>r3</td>
<td>Courtesy of person cleaning room</td>
</tr>
<tr>
<td>r4</td>
<td>Room temperature</td>
</tr>
<tr>
<td>r5</td>
<td>Noise level in and around room</td>
</tr>
<tr>
<td>m2</td>
<td>Temperature of the food</td>
</tr>
<tr>
<td>m3</td>
<td>Quality of the food</td>
</tr>
<tr>
<td>m4</td>
<td>Courtesy of person served food</td>
</tr>
<tr>
<td>n1</td>
<td>Friendliness/courtesy of the nurses</td>
</tr>
<tr>
<td>n2</td>
<td>Promptness response to call</td>
</tr>
<tr>
<td>n3</td>
<td>Nurses’ attitude toward requests</td>
</tr>
<tr>
<td>n4</td>
<td>Attention to personal needs</td>
</tr>
<tr>
<td>n5</td>
<td>Nurses kept you informed</td>
</tr>
<tr>
<td>n6</td>
<td>Skill of the nurses</td>
</tr>
<tr>
<td>t1</td>
<td>Wait time for test or treatments</td>
</tr>
<tr>
<td>t3</td>
<td>Explanations: happen during T&amp;T</td>
</tr>
<tr>
<td>t5</td>
<td>Courtesy of person took blood</td>
</tr>
<tr>
<td>t7</td>
<td>Courtesy of person started IV</td>
</tr>
<tr>
<td>v2</td>
<td>Accommodations &amp; comfort visitors</td>
</tr>
<tr>
<td>v3</td>
<td>Staff attitude toward visitors</td>
</tr>
<tr>
<td>p1</td>
<td>Time physician spent with you</td>
</tr>
<tr>
<td>p2</td>
<td>Physician concern questions/worries</td>
</tr>
<tr>
<td>p3</td>
<td>Physician kept you informed</td>
</tr>
<tr>
<td>p4</td>
<td>Friendliness/courtesy of physician</td>
</tr>
<tr>
<td>p5</td>
<td>Skill of physician</td>
</tr>
<tr>
<td>d1</td>
<td>Extent felt ready discharge</td>
</tr>
<tr>
<td>d2</td>
<td>Speed of discharge process</td>
</tr>
<tr>
<td>d3</td>
<td>Instructions care at home</td>
</tr>
<tr>
<td>i1</td>
<td>Staff concern for your privacy</td>
</tr>
<tr>
<td>i3</td>
<td>How well your pain was controlled</td>
</tr>
<tr>
<td>i4</td>
<td>Staff addressed emotional needs</td>
</tr>
<tr>
<td>i5</td>
<td>Response concerns/complaints</td>
</tr>
</tbody>
</table>

REFERENCES

FERAL INFORMATION SYSTEMS VIEWED THROUGH THE LENS OF STRUCTURATION THEORY

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ABSTRACT

A Feral Information System (FIS) is any information technology artefact that an End User employs instead of the mandated Information System. Structuration Theory provides a lens to view how Knowledge Workers have access to authoritative and allocative resources through the mode of domination and/or transformative capacity, to counter the traditional structures of domination that managers can employ. Further, a Knowledge Worker’s trajectory through time-space may provide Lebensstil (life style) opportunities that, if accepted, allow construction of a FIS. When Enterprise System suppresses a Knowledge Worker’s productions function, they may resort to constructing a FIS to recover lost producer surplus.

Keywords: Feral Information System, Structuration Theory, Knowledge Workers, ERP, Enterprise Systems

INTRODUCTION

The trigger for this research is first hand observations of End Users constructing Feral Information Systems (FIS) in a number of different organisations. Organisations invest considerable sums to install an Enterprise System and have it working correctly [46]. Its proponents expend further resources ensuring that the Enterprise System is favoured over other information artefacts. For all of the technological prowess and weight of organisational might behind the Enterprise System some End Users are in the position of being able to choose to ignore it [6, 35]; with a subset of this group being able to construct an alternative [25, 40]. While there is recent growing interest, research to date has been relatively sparse. Surprising when one considers that global investments in Enterprise Systems is $US21B [70] and estimates of failure rates ranges from 40% [53], to over 50% [2, 26, 52], and up to 70% [42, 44]. The larger PhD study, which this paper forms part of, is not part of an Action Research project. Whilst having worked full-time at one of the study sites for nearly 30 years, the first author is not part of the action or close enough to significantly influence the action [15, 36]. The advantage of the principal researcher’s position, however, is closer interaction with the environments under study than is afforded the casual researcher [6].

DEFINITION REVIEW FIS, EU, ES

Feral Information System are defined by Houghton and Kerr [40] as;

“... an information system that is developed by individuals or groups of employees to help them with their work, but is not condoned by management nor is part of the corporation’s accepted Information Technology (IT) infrastructure.”

This definition implies conditions that must be satisfied before labelling an artefact as a Feral Information System (FIS). First, the host organisation has a structure that supports centralise decision making for some or all aspects of its Information System (IS) needs. These structures often manifest a centralised Information System Department [13, 81]. Second, this Department has mandated the use of certain Information Systems for a specific whole-of-organisational process.

While accepting the general thrust of Houghton and Kerr’s definition, this paper notes other research that suggests End Users are not necessarily the exclusive constructors of FIS. An Information System can quickly turn from being the sanctioned system to one that the Information System Department is non grata about its usage, particularly post changeover to a new Enterprise System (ES). For example, consider a corporate Information System, originally constructed by the Information System Department. Post changeover it is now considered legacy. The End Users (EU), however, are continuing to employ the legacy system in defiance of the sanctioned new Enterprise System [33, 87]. The End Users have subverted the legacy systems into acting as a Feral Information System.

This paper proposes that Houghton and Kerr’s definition is refined to more simply state; “Any information technology artefact that an End User employs instead of the mandated Information System”. This definition draws its boundaries to exclude non-information technology artefacts, like paper-based systems. It also excludes desktop applications, like spreadsheets and desktop databases, provided the desktop application is not suborning the mandated processes.

Literature has other terms that overlap the definition of FIS: namely, Workarounds and Shadow Systems. Literature uses the term “workarounds” to describe actions that the End User has employed to manipulate the Information System and associated organisational processes. This spans actions that are either hostile to or supportive of the process of the host organisation. The literature often mentions the use of desktop spreadsheets and databases. Most of the
literature that discusses workarounds has the perspective of watching an End User attempting to resolve tension between the demands of the Information System and their immediate work needs [6, 11, 12, 25, 29, 33, 43, 45, 63, 68, 78, 82, 87, 88]. However, some of the literature on workarounds also includes End Users resorting to “tricks”, like the forced reset of the hardware’s system clock, to manipulate the Information System [11].

Other works apply the term “Shadow System” in a similar vein, describing the use of Information Technology artefacts to assist End Users overcome, whether perceived or real, inadequacies in the sanction Information System [9, 33, 62, 67, 76, 87]. While there are subtle differences in context, for practical purposes, this paper considers the terms FIS, Workarounds, and Shadow Systems in the literature as interchangeable. As an aside, this paper notes that the term ‘Skunk Works’ is more applicable to describe project teams, no matter how well hidden from the rest of the organisation, which have the imprimatur of the Executive. Using the expression Skunk Works in this context then remains true to the original Lockheed Advanced Development Projects Skunk Works concept [37].

The species of Information Systems that this paper is researching is the Enterprise System. Organisations install Enterprise Systems to dispense with isolated systems and provide seamless data integration across the business [16, 44]. The notion is that a common data repository improves horizontal communication across the business. Access to a common data repository; breaks down silos, improves data absorption, and allows self-directed reaction [80, 87] to changing environmental conditions. Common data repositories improve the functionality of system integration across organisational boundaries [17, 23, 28, 29, 44, 54]). Often the literature uses the terms Enterprise Systems (ES) and Enterprise Resource Planning (ERP) interchangeably [17, 77]. While this approach is common practice in the literature, it overlooks the concept there are other Enterprise Systems that do not share their ancestry with ERP. ERP systems have evolved from Material Requirements Planning (MRP) software, which IBM developed in the late 1960’s for manufacturing plants. Gartner coined the term Enterprise Resource Planning, commonly abbreviated to ERP, in the early 1990’s. Gartner’s criteria for distinguishing and ERP from an MRP was the degree of horizontal integration across organisational silos [74]. Current ERP offerings include end to end business solutions for the entire organisation [34].

**REVIEW OF LITERATURE RELATING TO ERP/ES**

Organisations implement Enterprise Systems to improve business decision making, streamline the business processes, improve productivity, and lead to increased profitability [8, 39, 44]. For government and non-profit organisations Enterprise Systems are used to increase social good [35]. Implementing an enterprise system, however, is a complex undertaking [8, 45, 79], which involves considerable risk to the organisation. The expectation is that the rewards will be equally consummate with the risk [39, 55, 72, 80]. There is a substantial body of academic research available into why some enterprise systems succeed when others fail. A typical approach employed by researchers is a study of the Critical Success Factors [2, 5, 23, 26, 53, 58, 59, 69, 80, 90]. When comparing the works from the various authors, no clear consensus emerges from the literature as to a definitive list of Critical Success Factors. While there is a diverse range of views in the literature as to what the Critical Success Factors actually are, common themes keep reappearing.

First, the support of Senior Executives plays a key role in ensuring implementation success. Enterprise System implementations tend to create organisational tension. If the installation has asymmetrical impacts on the organisation, in particular positive impacts for its proponents and negative impacts for its opponents, some resistance is to be expected [29]. For example, instead of being in the best interests of the organisation, some use the implementation as a mechanism to promote their interests [57]. Another example is when proponents have a hidden agenda in the implementation with the goal to increase personal utility [42]. At times, these tensions can only be resolved at the Executive level.

Second theme emerging from CSF analysis is that organisations must select the correct system for the intended application. While the statement may be self-evident, it also simplistic in that understates the complexity in the selection process. Subtle and apparently minor differences that evaluation teams note in competing products may turn out to have major ramifications. Differences that is not apparent until after an organisation has committed significant resources to the project, perhaps when the project is beyond the point of no return [54]. For example, the software may be too generic for the organisation’s needs [55]. Enterprise Systems are so intricate that most firms rely on the assistance from specialist consultancy firms [75]. Compounding the selection process are the occasions when the vendor knowingly supplies a product that does not suit the intended application [69].

The third theme from the literature on Critical Success Factors was attention to Business Process Re-engineering (BPR). Up until the early 1990’s, large organisations often wrote bespoke software to suit their business processes. There was a movement to reverse this practice during the 1990’s. Organisations were encouraged to accept, what is termed in the industry as, “vanilla” or “shrunken wrapped” software [61] from the vendors and re-engineer their existing business process to suit the software. Some consider BPR to be a form of neo-Taylorism [73]. If managers choose to install vanilla software, by default, they are agreeing to change their business processes to suit the software [8, 29, 44, 50, 51, 69, 71, 80, 88]. There are many other factors involved in BPR and an extended discussion is beyond the scope of this paper. Suffice to say that BPR now appears to have been a managerial fad of the 1990’s [27]. However, implementation teams must remain cognisant that Enterprise Systems will affect existing business process and take appropriate steps to manage the change.
The remaining discussion points in the literature on CSF include project management over implementation and cost control. In addition, there is a miscellaneous collection of other items considered critical by individual authors. A non-exhaustive list includes; good communication, lean team, access to specialist staff, change champion, training, and ERP configuration. This paper concludes that, while Critical Success Factors is useful information to avoiding common pitfalls, the continual high failure rate of Enterprise System implementations suggests that adherence to CSF alone does not provide all of the required answers.

**FERAL INFORMATION SYSTEM**

The Feral Information System concept was developed from a qualitative study at a large, mature, public Utility. The researchers were seeking to understand why the recent implementation of a large SAP R/3 was not as successful as originally envisioned. During the study, the researchers noted End Users developing and using alternative information technology artefacts, mainly in the guise of desktop spreadsheets, to the managerially sanctioned SAP Enterprise System. In one example, the employees were deliberately entering incorrect quantities of critical long-lead stock items into SAP, whilst tracking the true quantity in a spreadsheet. Further, the stock in question was stored in alternate locations to the nominal warehouses to hide it from the auditing process. In this instance, the employees were not engaging in embezzlement. Rather, they had built a hidden stockpile to accommodate operational requirements [41].

In untangling the issues, the researchers noted that the financial arm of the Utility was using SAP to drive down inventory holdings to save costs. However, this was at odds with the operational arm of the Utility that believed it needed a certain holding of this long-lead stock for emergencies. There were additional benefits in holding a large buffer stock. It covered inefficiencies in the upstream planning process for ordering long-lead plant items. The researchers drew on Foucault’s work to theorise that part of the problem was unresolved tensions in the “power relationships” between engineering and financial managers. End Users resorted to building an Feral Information System, to bypass the Enterprise System, in an attempt to resolve these power tensions [49]. The actions of End Users resorting to spreadsheets and desktop databases to facilitate their immediate information requirements are not a new phenomenon. It has a history that dates back at least three decades, with research in this area often referring to it as End User Computing.

**END USER COMPUTING**

The literature on End User Computing notes the arrival of the desktop computer, particularly the IBM PC and the Apple, in the early 1980’s as a significant change in the history of information technology [3, 10, 14, 20]. It would be a mistake to assume, however, that the arrival of the personal computer marks the start of End User Computing per se. There is commentary that End Users were struggling for access to computing resources on the mainframe for their own needs as far back as the 1960’s [83]. Knowledge workers, particularly engineers and scientists, were the vanguard of End User Computing in early epoch of computing [10]. Pre-dating the arrival of the PC there was debate in the MIS community over the concept of End Users writing applications in the then mainframe computing environment [56]. As late as the mid-1980’s, well after the introduction of the personal computer, over 70% of End User Computing was still occurring in the mainframe environment [3].

Some common themes emerged from a read of the literature. First, organisations face considerable installation and ongoing maintenance costs associated with Information Technology. For some End users, there is an allure in using the latest IT to displace previous manual work methods. Some managers are suspicious that End Users are distracted from doing real work in favour of playing with the latest IT. In economist’s terms, it is difficult for senior managers to separate End User “wants” from “needs”. Managers respond by instigating mechanisms to contain these costs, which leads to the second theme in the literature [60]. Most organisations responded by creating a centralised Information System Department (ISD) to contain costs.

Second, organisational tension then develops between the ISD and the End Users. End Users perceive the ISD as slow and unresponsive to the IT needs of other departments. There are examples from the mid 1980’s of ISD taking up to four years to create a report [3, 30]. Third, End Users respond by resorting to End User Computing to meet their immediate business needs, typically to improve Departmental operational flexibility. The fourth theme of note, particularly in the earlier literature is how Knowledge Workers as at the vanguard of End User Computing. Building a Feral Information Systems requires some degree of innovation. End User innovation in defiance of the managerial sanctioned tool set is not restricted to constructing IT artefacts; it was alive and well long before the information age [84-86].

**FIVE ROLES OF AN INFORMATION SYSTEM**

The Five Roles of an Information System is a theory developed by Askenis & Westelius [7]. By adapting elements of Gidden’s Structuration theory, it examines how well the Information System matches the host organisation to derive an “IS fit with structure”. The IS Fit can range from poor to good. The second dimension of Five Roles is the level of control individuals have over their actions. This is termed “Direction of Control”, which ranges from the individual being able to control their actions to the Information System controlling the user’s actions. Drawing from Actor network Theory (ANT), Askenis [6] assigned actor roles that the information system assumes within the organisation. From these two dimensions, there is a quadrant of possible actor roles. In the half of the quadrant where Information System is in control of the actions: if there is a good fit between the IS and the organisation the system is classified as a “Bureaucracy”. If the Information System is in control and the fit is poor, Five Role Theory
classifies the system as a “Manipulator”. In the half of the quadrant where the individual controls the actions; if there is a good fit between the IS and the organisation the system is classified as a “Consultant”. If the individual is in control but the fit is poor, it is classified as an “Administrative Assistant” [6]. Figure 1 is a sketch of the four roles.

The fifth role in the theory, the “Dismissed” state, does not fit into any of the quadrants. In the Dismissed role, the End Users have rejected the Information System by deliberately choosing not to use it. In her case study, Askenäs [6] noted the salespeople had turned their ability to generate income for the company into strong bargaining power to overcome the Information Systems’ inherent power. The salespeople put forward the argument that using the Information System was affecting their productivity, reducing the company’s income. Hence, the salespeople had arranged to dismiss the Information System from interacting with them in any of the possible actor roles. Askenäs [6] did not explore beyond the dismissed state. Her work is silent on whether there is a predisposition for End Users to reside on one or more of the four roles before entering the Dismissed role. This paper assumes that users who place the ERP in the Consultant role would be unlikely to progress to placing the ERP in the Dismissed role; whereas End Users who consider the ERP as a Manipulator or Bureaucrat would be more inclined to progress to the Dismissed role. As discussed earlier, there is a realm of End Users who not only dismissing the Information System, but developing an alternate Feral Information System as well. This paper accepts Askenäs [6] novel extension of Structuration Theory as a bridge towards deeper understanding of why End Users create Feral Information Systems.

**STRUCTURATION THEORY**

Structuration Theory grew out of Giddens’ early works on the writings of Marx, Webber, and Durkheim. For a theoretical framework that makes almost no mention of Information Technology, it has been widely cited by researchers interested in Information Systems [48]. It is a body of work that broad, deep, and dense. Reviewers have generally found it difficult to succinctly summarise his works [48, 89]. Comprehensive works that translate Structuration Theory to Information Systems include DeSanctis & Poole [18], Ferneley & Sobreperz [25], and Orlikowski [68]. This paper will concentrate on selectively appropriating elements of Giddens’ work for application. An approach endorsed by Giddens [48].

Giddens nominates three dimensions of structure: signification, domination, and legitimation. The related dimensions of interaction are; communication, power, and sanctions. Structure and interaction are linked through the modalities of; interpretive schemes, facilities, and norms. While Giddens loosely drew this as a table in Central Problems in Social Theory [31], secondary literature prefers the slightly clearer schematic provided in The Constitution of Society [32], which is reproduced in Figure 2

Of particular interest to this research are the modes of domination. Domination involves asymmetries in resources that is then used to sustain power in relationships [31]. In Structuration theory, the two main resources that provide domination are allocative and authoritative [31, 32]. Allocative resources is the capability “… to generate command over objects or material phenomena …” and authoritative is the capability “… to generate command over persons …” [31]. Of use is Gidden’s concept of how resources are the media of domination and access to a transformative mechanism. Transformative capacity in turn can feed back into the original mode of domination. If human agents have access, they may use authoritative and allocative resources in either modes of domination or transformative capacity on the structure of domination [31].

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**Figure 1 Quadrants of Five Role Theory adapted from Askenäs (2004)**

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**Direction of Control**

**IS controls actions**

<table>
<thead>
<tr>
<th>IS fit with Structure</th>
<th>Good Fit</th>
<th>Poor Fit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bureaucrat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manipulator</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consultant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Administrative Assistant</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Individual controls actions**

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**Dismissed Window**

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**The 11th International DSI and the 16th APDSI Joint Meeting, Taipei, Taiwan, July 12 – 16, 2011. pp.101-110**
DOMINATION OVER THE MEANS OF PRODUCTION

One definition of a knowledge worker is a person who, has formal education, the aptitude to employ both theoretical and empirical knowledge, the ability to think differently, and a commitment to continuous lifetime learning [21]. For the purposes of this paper, the interest in knowledge workers is that they own the means of production. As Drucker eloquently states:

“Employees who do manual work do not own the means of production. They may, and often do, have a lot of valuable experience, but that experience is valuable only at the place where they work. It is not portable. Knowledge workers, however, own the means of production. That knowledge between their ears is a totally portable and enormous capital asset. Because knowledge workers own their means of production, they are mobile.”[22]

Under Structuration Theory, this chances the structures of domination. As Knowledge Workers have access to the primary resources, the means of production between their ears, they are able to have some influence on the mechanisms of transformative capacity. As Drucker notes, Knowledge Workers are not able to achieve total dominance. For most, the relationship between the host organisation and the Knowledge Worker is symbiotic [22]. This paper argues that Enterprise Systems are attractive to owners by their promise to increase the owner’s control over allocative and authoritative resources. Owners have access to allocative resources because Enterprise Systems are a means of production, the purpose is to extract additional surplus value out of the workers. The Taylorist approach embedded in Enterprise Systems provides increase control over allocative resources within the organisation [38]. Owner’s gain access to increased authoritative resources through the built in workflow and auditing mechanisms programmed into the Enterprise System.

Some argue that managers are seeking to increase their span of control over Knowledge Workers [42]. Conflict can then arise between the Enterprise System and the Knowledge Workers. Particularly, if the means of production imposed by managers, in the form of the Enterprise System, clashes with the means of production desired by Knowledge Workers. This tension can lead to a power struggle. A Feral Information System within organisations can be one possible expression of this struggle of control over allocative and authoritative resources. While literature notes the existence of Feral Information Systems (and the associated terms Workarounds and Shadow Systems), they are not ubiquitous and do not routinely appear at every clash between Enterprise Systems and Knowledge Worker. This paper suggests that other facts are at play including Lebenschancen and Production Functions.

LEBENSSTIL (LIFESTYLE)

Why is it that sometimes End Users who reject the Enterprise System build a replacement, while at other times they do not? For example, on one hand, Askenäs [6] noted how salespersons (End Users) rejected the Enterprise System but did not build an alternate. It was left to the organisation to respond by building a custom-made interface for the salespeople. On the other hand, Houghton and Kerr [41] also noted End User rejection of the Enterprise System. In their case study, the End Users rejection also included the development of Feral Information Systems. Recall the earlier discussed examples of Workarounds and Shadow Systems, plus extensive literature recording over forty years of End User Computing. One self-evident factor would be the skill set of the individuals in any given situation. If they have only basic computer skills, they are not in the best position to develop a Feral Information System.

Lebenschancen (life chances) along with Lebensführung (life conduct) are the two basic components of Weber’s Lebensstil (lifestyles). Unfortunately, there is a dearth of independent translations of Weber’s work into the English language. With some expressing concern that the sparsely available English works do suffer key mistranslations from the original German [1]. To avoid paraphrasing inducing any further derogation of Weber’s work, Abel and Cockerham’s interpretation is reproduced below.

Weber used three distinct terms to express his concept of lifestyles. These terms are "Lebensstil" or "Stilisierung des Lebens" which mean lifestyles, and "Lebensführung" (life conduct) and "Lebensschancen" (life chances), which comprised he two basic components of lifestyles. Lebensführung refers to the choices people have in their

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selection of lifestyles and Lebenschancen is the probability of realizing these choices. In Anglo-American sociology, the link between choice and lifestyles appears to have been overemphasized, while the connection between lifestyles and life chances has received little attention.’[1].

Giddens makes a direct, but brief, mention of ‘life chances’ as part of his Structuration framework when discussion its interaction with authoritative and allocative resources; including the mobilisation of these resources across time-space [32]. While direct discussion is sparse, clearly Giddens was aware of the impact of life chances. For example, the existence of homeostatic loops across generations in the cycle of being brought up in poverty, poor schooling, low-level employment, which leads to poverty upbringing for the next generation [31]. Other applications of Structuration theory to information system problems, for example Orlikowski et al [63-68], appear to make no use of Webers’ Lebensstil. This paper suggests that has an important role to play in the development of Feral Information Systems.

Lebensstil forms part of the theoretical bridge between Askenäis [6] Five Role Theory and Houghton and Kerr [41] work on Feral Information Systems. For a Feral Information System to exist, End Users must first be in a position to be able to “dismiss” the Enterprise System. Next, End Users must have had a suitable Lebenschancen and then chartered a course of Lebensführung to arrive at a space-time point were these skills provide the opportunity to construct a Feral Information System. For the best part of fifty years, knowledge workers, particularly scientists and engineers, have been teaching themselves to write computer applications to suit their immediate work needs. Knowledge workers are, by their very nature, self-motivated individuals who have the ability to acquire knowledge and techniques.

PRODUCTION FUNCTIONS

This paper accepts the premise that workers are rational agents who seek to maximise their reward and minimise their costs [24]. To prevent shirking, organisations employ monitoring. The level of monitoring is a function of the cost of monitoring verse the additional productivity gained from monitoring. Owners engage managers to act as their agent in monitoring workers to reduce the incidences of shirking [4]. The unskilled worker and the data operator have limited latitude in their work scope. It is relatively easy to monitor the unskilled worker’s productivity. However, when the workers are Knowledge Workers, they have considerable scope and freedom in the role. Owners and managers face higher monitoring costs of Knowledge Workers. Hence, there is a higher degree of trust placed in Knowledge Workers and this is realised through autonomy and responsibility [22].

Organisations face a range of costs; simple production costs, transactions costs, and information costs [4]. One approach taken is to express simple production costs in the form of a function,

\[ V = f(C, K, L), \]

Where C = IT Capital, K = Non-IT Capital, L = Labour [19]. The point here is that firms have some discretion in how they manage their inputs. For example, how firms allocated funds between IT Capital costs (C), Non-IT Capital (K) costs, and Labour (L). Indeed, organisations are investing in IT Capital in a manner that “displaces other inputs” [19]. This is not the limits of a firm’s costs; there is also the allocation of funds to monitor agents undertaking transactions on the firm’s behalf. Like the firm, Knowledge Workers find themselves burdened with tasks, which are effectively “costs”, which subtract time away from their primary task [22]. Knowledge Workers often have a choice of techniques (read inputs). Some of the techniques employed may include partial constructed or fully constructed technological artefacts. Some supplied by the firm, others supplied by the Knowledge Worker.

This paper proposes that Dewan and Min’s [19] production function for the firm can be adapted to gain insight to the production function for an individual Knowledge Worker. Dewan and Min’s [19] treated all labour (L) inside the firm as being equal. Because Knowledge Workers own the means of production (Drucker 1999), this paper proposes that Knowledge Worker labour and other labour can be treated separately. Unskilled labour can only provide unskilled labour. However, a Knowledge Worker can alternate between their own means of production and unskilled labour. Applying ration agent theory, Knowledge Workers will select a mix of inputs that will maximise their rewards and minimise their costs. These costs are unique to each individual: not only for their current position in time-space, but inclusive of their trajectory through time-space (i.e. Lebensstil). The use of supplied Information Systems, own artefacts (i.e. Feral Information System), and labour also implies an associated transaction and information cost. For example, if the Knowledge Worker elects to use an artefact supplied by the firm, the Knowledge Worker must accept information costs to learn how to use the artefact. An example of transactional costs may be the costs associated to extract data from the Enterprise System and translate it into a format that is used by their artefact. Another cost may be the effort to bypass the security systems around the Enterprise System so the End User can extract the required data [13]. However, when the Enterprise System is a good fit with the needs of the Knowledge Worker and it allows them to feel in control of the actions, the production function strongly encourages the Knowledge Worker to stay with the Enterprise System.

Earlier, this paper discussed End User Computing. We noted that even when only mainframe computing was available, End Users were constructing programs and reports outside the nominal boundaries of the support provided by the IS Department. In other words, End Users were substituting the own artefacts for the firms IT Capital.
investment. The division between IS Departments and the rest of the organisation is even clearer post arrival of the personal computer, were literature provides numerous examples of End Users constructing Information Technology artefacts on desktop computers that the Information System Department did not even know existed. Some Knowledge Workers are prepared to reallocate their resources over the short term in such a manner that will increase the ability to build/improve artefacts: with the overall goal of increasing rewards and/or minimising costs in the long term.

Positioning this formula inside Gidden’s Structuration Theory adds richness. There could be various norms and practices [31] at the workplace that alter how and when Knowledge Workers substitute their artefacts for the firm’s artefacts. Not using the firm’s artefact may invoke some form of a sanction. Alternatively, the firm’s environment may tolerate or even actively encourage End User Computing [47]. This alters the input cost structure for the Knowledge Worker in a way that is hard to capture in a formula. Balancing the modes of sanction is our earlier discussion that Knowledge Workers often have access to allocative resources that they can harness in a transformative capacity. A certain Knowledge Worker may be so valuable to the firm that it will tolerate his/her rejection of the Enterprise System.

Theoretically, an investment in IT Capital should only proceed when it will have a positive impact on the production function of the organisation. There are, however, examples of Enterprise System implementation, which this paper discussed earlier, where the change in production function is asymmetrical across the organisation. This includes; negative impacts on individual’s production function [29, 42, 57], use the implementation as a mechanism to promote self-interests [57], and hidden agendas in the implementation with the goal to increase personal utility [42]. Direct examples include Askenäis [6] noting how the salespeople felt the new ERP reduced the time they could spend on sales. Kerr, Houghton, and Burgess [49] noted how the new ERP reduced buffer stock, which the End Users felt was an impact on their productivity. We argue that when Knowledge Workers believe the Enterprise System is suppressing their production function the opportunity is ripe for the genesis of a Feral Information System.

CONCLUSIONS

This paper draws the following conclusions from the literature. First, Enterprise Systems still have an unacceptably high implementation failure rate. Second, implementation proponents assume that their modes of domination will be sufficient to override any structural dislocation that the Enterprise System may cause. If there is good fit between the Enterprise System and the recipient organisation, this assumption will stand untested. Third, if the implementation proponent’s modes of domination are supreme, the End Users have few options other than use the system. Although, this in itself does not guarantee that the Enterprise System will be a success in the long term.

Fourth, in some organisations, the implementation proponents operate in a structure where some End Users also have access to powerful authoritative and allocative resources through the mode of domination and/or transformative capacity. In these circumstances, if there is poor fit between the Enterprise System and the End User’s needs, the End User can reject the Enterprise System and there is little that the Enterprise System proponents can do to challenge this rejection. Fifth, rather than resort to direct rejection, some End Users have the capability to give an outward appearance of Enterprise System acceptance while developing hidden artefacts, called Feral Information Systems. Feral Information Systems operate in a broad spectrum; at one extreme being a helper application to the Enterprise System through to the other extreme of replacing the Enterprise System.

Feral Information Systems will not necessarily arise in circumstances where the End User has access to modes of domination and/or transformative capacity. Webber’s concept Lebensstil, explain why some End Users have the capability to create a Feral Information System, while their colleagues with apparently similar qualifications cannot. Lebensstil explains why some identical circumstances can result in a range of Feral Information Systems, from primitive to sophisticate. However, access to modes of domination and ability to create are not enough to drive the creation of a Feral Information System. Economic theory informs that most End Users are rational agents. When the Enterprise System affects the End User’s production function, there is economic pressure on the End User to recover lost production surplus.

These conclusions present a number of interesting research opportunities. First, develop a qualitative study of End User perceptions over loss of production function. Second, collect quantitative data that can measure loss of production function. Third, explore the premise that Lebensstil is a variable in the creation of Feral Information Systems through demographic data including education, employment history, age, etc. Forth, explore the modes of domination that FIS creates feel subject to or are able to subjugate.

Increased understanding around the circumstances that lead to the creation of Feral Information Systems could lead to developments that ease the tension between Enterprise Systems and the End Users. In turn, Enterprise Systems can become more efficient and accommodating of End User requirements. A reduction in End Users having to divert resources into Feral Information System will free up this production capacity for more productive purposes.

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CUSTOMER ORIENTATION, JOB DEMANDS-RESOURCES AND JOB SATISFACTION: A CROSS-LEVEL PERSPECTIVE

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ABSTRACT

This study developed and tested a cross-level model of individual job satisfaction, integrating research on customer orientation and the job demands-resources model. Using hierarchical linear modeling on data collected from 431 employees from 35 restaurants in Mongolia, the study found cross-level interactions between employee customer orientation, job demands-resources and organizational-level customer orientation. The study found that employee customer orientation and job resources were positively related to job satisfaction, while job demands had no significant direct effect on job satisfaction. Further, organizational customer orientation was found to moderate the impact employees’ job demands and job resources have on job satisfaction. The study discusses both the theoretical and practical implications of these findings.

Keywords: customer orientation, job demands, job resources, satisfaction, cross-level analysis, service industry.

INTRODUCTION

Two important and recurring questions in organizational science are why employees perform well in their jobs and why they are satisfied with their jobs [1]. Research on the job demands-resources (JD-R) model suggests that employees’ job outcomes (i.e., job performance, turnover) depend on job characteristics such as job demands (e.g., work pressure, role overload, work-home interference) and job resources (e.g., job control, peer support, financial reward) [2-3]. Empirical evidence also confirms that various individual-based variables (e.g., personality, motivation, behavior) and organization-based variables (e.g., climate, leadership) may play an important buffering role in this respect, that is, in enhancing or mediating the positive effect of job characteristics on job outcome [4].

A variable which is found on both the individual and organizational level is that of customer orientation. Despite its economic significance, there exists considerable variance in the extent to which customer orientation is practiced [5]. At the individual-level, employee customer orientation (ECO) refers to an individual’s tendency or predisposition to meet customer needs in an on-the-job context [6]. Organizational-level customer orientation (OCO) on the other hand refers to the degree to which the climate or culture of the organization is conducive to meeting customer needs [7]. Both levels of customer orientation put the customer’s interest first, while not excluding those of all other stakeholders, in order to develop a long-term profitable enterprise. Employees play a truly crucial role in any organization as their attitudes towards customers determine customer satisfaction, which in turn impact employee outcomes as well as organizational outcomes [8]. By becoming more responsive to the customer and his/her needs, customer retention can be increased. Discussing the imbalance of macro (organizational-level) customer orientation versus micro (individual-level) customer orientation, employees’ perceived customer orientation of the organization affects how customer-oriented they themselves become, as employees respond to the policies of their organization [8]. This may also influence employee satisfaction, as employees in a service environment should be more satisfied when they feel supported by their organization’s policy towards customers.

While personality factors and stress factors have recently received an increased attention in terms of their roles as moderators or mediators to the relationships between job characteristics and its outcomes [3, 9-10], there has been little research to date exploring how OCO moderates the impact of individual-level differences on job satisfaction. Hence, this study explores multilevel model using hierarchical linear modeling (HLM) to study such cross-level influences of individual differences (ECO and JD-R) and the OCO context on individual job satisfaction.

Building upon and extending previous research, our study seeks to answer two research questions. Our first research question is to determine in what way individual differences (ECO and JD-R) influence job satisfaction. The absence of research on this issue is surprising given that ECO has received much attention in terms of frontline employees [11] and that the JD-R model has been shown to mediate the influence of employee burnout on workplace behaviors [12]. Given the significance of individual customer orientation [6], the importance of the JD-R model in terms of its impact on work outcome [1], and the crucial role that employee-customer relationships play in a competitive marketplace [10, 13], these issues warrant attention. We therefore investigate the influence of ECO and JD-R on job satisfaction.

Our second research question examines the moderating role of a company’s OCO on the relationship between individual differences and job satisfaction. As Whelan et al. [7] acknowledges, little research exists on the role of OCO in service settings. Although market orientation (of which OCO is one) has been shown to affect employee outcomes (i.e. job satisfaction), research aimed at understanding its moderating influence on individual-difference variables is lacking. Babakus et al. [8] and Whelan et al. [7] contribute to this area by revealing that OCO should be considered when managing employee behavior and job characteristics. However, no work has been done related to cross-level influences of the OCO context and individual differences on individual outcomes. This is a notable shortcoming given that individual differences and organizational variables jointly determine outcome. On the following pages, we begin by briefly...
reviewing the two levels of customer orientation and individual differences to develop hypotheses that relate to their impact on an individual’s job satisfaction. Next, we describe the research methods, followed by our empirical results. Finally, we conclude with a discussion of the findings, managerial implications and future research avenues.

CONCEPTUAL DEVELOPMENT AND HYPOTHESES

Customer orientation

It is well established among marketing theorists that firms which focus their activities on the needs of their customers, i.e. behave in a customer-oriented way, perform better than those companies that do not [5]. Customer orientation has been conducted at two levels of analysis – the organizational level [14] and the individual level [6]. Both levels of customer orientation are considered an important leverage for organizations’ economic success and lead to the development of long-term relationships with customers.

Research at the organizational level has focused on the concept of market orientation, which essentially creates tenets of organizational behavior with respect to a firm’s customers and competitors. Based on market orientation research, an organizational-level customer orientation (OCO) is defined the degree to which the climate or culture of the organization is conducive to meeting customer needs [7]. In contrast, research at the individual-level relates to the interpersonal contact between employees and customers. An employee customer orientation (ECO) is an employee’s tendency or predisposition to meet customer needs in an on-the-job context [6]. Donavan et al. [5] consider that any particular employee’s customer-oriented behavior will result from the combination of person (e.g., personality, goals, functional motives) and environment (e.g., nature of the job, short-term situational effects). This shows that the OCO climate perception will impact an employee’s customer orientation. It is thus necessary to consider both the pervasive set of values and beliefs that serve to consistently reinforce the organization’s customer focus as well as information about the actual needs of customers [14]. Management may therefore benefit from gaining an understanding of employees’ perceptions of the OCO climate, as it can help determine climate improvement goals in order to most effectively impact important personal outcomes such as the behaviors, attitudes, beliefs, values, and motivations of people within the work environment.

Our research framework is presented in Figure 1, which shows how both individual level and organizational/unit level based perceptions impact job satisfaction. In terms of individual level-based perceptions we suggest that individual differences such as employee customer orientation, job demands, and job resources will affect the employee’s job satisfaction. We further suggest that perceptions of the OCO moderate the individual differences. Our framework is consistent with the notion that the effects of employee’s behavior (i.e., ECO) and job characteristics (i.e., JD-R) on employee outcome (i.e., job satisfaction) intuitively depend on conditions (i.e., OCO) under which the ECO and JD-R model are perceived to relate realistically to outcome [7]. OCO provides a means of understanding how the environment might give rise to such conditions. In the next section we derive specific hypotheses with respect to the linkages among individual and organizational level variables and job satisfaction.

Figure 1. The conceptual model

Employee customer orientation and job satisfaction

This study investigates influences on job satisfaction, which is an important job outcome often related to employee’s behavior and attitude, and which helps address the long-term viability of organizational development. It is a topic that has been widely researched in previous studies. Job satisfaction is viewed as having many facets, including satisfaction with pay, tasks performed, individual personality, organization policies and interaction with coworkers [15]. Job satisfaction has further been demonstrated to have an important relationship with a number of job outcome variables, such as intention to leave, stress, turnover, and performance [14].

Employees’ customer-oriented behavior influences their performance [6]. In order to be customer oriented, the employee has to be motivated to expend greater effort, relative to the sales orientation, in customer-related interactions [11]. Because employees who exhibit a high degree of customer orientation engage in behaviors that increase the satisfaction of their customers; employees’ high levels of customer orientation enhance consumer views of the organization’s reputation through positive interactions with the employees [5]. Moreover highly customer-oriented employees experience higher levels of job satisfaction, where those employees with a low customer orientation are not only less likely to be satisfied with their jobs but also have to force themselves to comply with the job rules. Such efforts consume emotional and cognitive resources and ultimately lead to burnout [8].

Based on the above, the following hypothesis is proposed:

Hypothesis 1: Employees’ customer-oriented behavior positively affects the employees’ level of job satisfaction.
Job demands-resources and job satisfaction

The Job Demands and Resources (JD-R) model suggests that employee well-being is related to a wide range of workplace variables that can be conceptualized as either job demands or job resources, irrespective of the occupational context under study [3]. Job demands are defined as those aspects of the work context that tax employees’ personal capacities and are, therefore, associated with certain psychological and/or physiological costs [2]. Depending on the job context under study, the category of job demands can contain job characteristics as diverse as task interruptions, workload, work-home interference, organizational changes, and emotional dissonance [3]. The category of job resources is defined as those physical, psychological, social, or organizational aspects of the work context that (1) can reduce the health-impairing impact of job demands, (2) are functional in achieving work goals, and (3) stimulate personal growth, development, and learning [12]. Like job demands, the category of job resources contains various job characteristics such as opportunities for skill utilization, supervisor support, financial rewards, and career opportunities.

This is in line with the JD-R model, which states that job demands are the main initiators of the health impairment process that leads to negative organizational outcomes, while job resources are the most crucial predictors of engagement and consequently, of positive outcomes [16]. For example, Schaufeli et al. [12] found strong evidence that work pressure and emotional demands predict the exhaustion component of burnout. According to activation theory, there will be inverted U-shaped relationships between job demands and both job performance and job satisfaction [1]. That is, an increase in job demands is assumed to be beneficial for job performance and job satisfaction to, but not beyond, a certain level; after attainment of that optimum level of job demands, job performance and job satisfaction should start to decline.

In contrast to the energy-depleting role of demands, resources trigger a process that enables individuals to achieve their goals, leading directly to positive affective outcomes such as organizational commitment [12]. For example, employees with positive self-evaluations (a personal resource) are more likely to strive to fulfill goals and, in the process, to experience greater job satisfaction [17]. Further tests of the JD-R model in a sample of volunteers working across a range of formal volunteer organizations show that high demands are a significant predictor of stress, and high resources are significant predictors of job satisfaction [16]. A study that focuses on two specific job demands (e.g., work overload and work-home interference) and two specific job resources (e.g., job control and peer support) found these to be important determinants of the well-being of employees.

Based on the above discussion, the following hypotheses are thus offered:

**Hypothesis 2**: Employee job demands negatively affect employee job satisfaction

**Hypothesis 3**: Employee job resources positively affect employee job satisfaction

Moderating role of organizational-level customer orientation

Organizational-level customer orientation (OCO) is defined as the degree to which the climate or culture of the organization is conducive to meeting customer needs [7]. Based on the Pervin’s Goals Model [18], Whelan et al. (2010) posit that individuals are driven to accomplish various goals, and the environment is viewed as offering reinforcement opportunities to meet these goals and/or barriers to the accomplishment of these goals. Thus, an employee’s customer-oriented behavior will result from the combination of person and environment [5] based on the joint influences of personality, elemental, compound, and situational traits as well as the specific environment [8]. This means that for employees, the perceived customer orientation of the organization influences how customer-oriented they themselves become, as employees respond to the policies of their organization. This may also influence employee satisfaction, as employees in an organizational-level customer-oriented environment should be more satisfied when they have high levels of ECO. In this way OCO may moderate the relationship between ECO and job satisfaction, and we therefore propose the following hypothesis:

**Hypothesis 4**: OCO positively moderates the positive relationship between ECO and job satisfaction such that the beneficial effects of ECO will be stronger at higher levels of OCO.

According to the transactional theory of stress and emotion [19], individuals engage in primary appraisals to assess the significance of an environmental condition (e.g., threat, challenge, or loss) to their well-being. Babakus et al. [8] specifically suggest that OCO is a potentially important coping resource and should be an integral part of employee burnout and performance models. Their study found that the performance of employees with low OCO decline faster as job demands (stressors) increase. They further state that the buffering effect of OCO on the relationship between job demands and job performance may be due to the nature of OCO as a critical resource which helps the conservation of cognitive and emotional resources (self-control strength) needed to perform effectively [8].

OCO not only plays a critical role in the primary appraisal of job demands, but also serves as an organizational condition to alleviate the effects of job demands on job satisfaction. Employees operating within high OCO environments appraise job demands (stressors) to be less threatening than those operating within lower OCO environments due to their natural disposition to view the work environment and people around them with a customer service focus [8]. Furthermore, employees within high OCOs can better read the needs of customers and enjoy solving their problems, which gives them the ability to cope effectively with stressors to neutralize or reduce the detrimental effects of job demands on job satisfaction. In other words, their strong disposition to enjoy serving customers should serve as an internal resource for sensing what needs to be done in order to cope effectively with potential conflicts with customers, supervisors or coworkers, as well as ambiguities.
and role overload. Based on the above discussion, when employees within high OCOs encounter stressors in their work environment, such stressors are less likely to negatively impact job satisfaction as the high OCO reduces the negative outcomes of the stressors (job demands). Based on this, we advance the following hypothesis:

**Hypothesis 5:** OCO positively moderates the negative relationship between job demands and job satisfaction such that the detrimental effects of job demands will be weaker at higher levels of OCO.

Bakker and Demerouti [3] state that job resources play both intrinsic and extrinsic motivational roles, where work environments that offer employees growth, learning, and development impact the employees’ willingness to invest their efforts and abilities to the work task on hand, thereby supporting them in achieving work goals. In such environments it is therefore likely that the task will be completed successfully and that the work goal will be attained. For instance, a high OCO climate motivates employees to engage more with customers, and when the performance feedback is positive, it increases the likelihood of an employee being successful in achieving his or her work goals. Thus, whether high levels of OCO help satisfy employees’ basic needs or achieve their work goals, the outcome is positive [2].

As mentioned, job resources reduce the impact of job demands on strain, which help engaged workers successfully control and have an impact upon their work environment [20]. Further, according to Conservation of Resource (COR) theory [21], individuals have a tendency to conserve and accumulate valuable resources, such as work conditions, job rewards, colleague support and personal energy. COR theory predicts that personal and job resources such as belief in own capability may increase or lead to outcomes like better coping. This increased coping capacity may increase the impact of resources under various organization-based conditions (e.g., organizational climate and OCO). Although little empirical evidence has thus far been gathered, theoretically, on the basis of the JD-R model and above discussion, we can expect OCO to moderate the relationship between job resources and its outcomes. We therefore advance the following hypothesis:

**Hypothesis 6:** OCO positively moderates the positive relationship between job resources and job satisfaction such that the beneficial effects of job resources will be stronger at higher levels of OCO.

**METHOD**

**Sample and data collection**

The Mongolian restaurant sector is expanding, mirroring the growth in travel and disposable income. Owners and managers of restaurants must balance the need for profit and customer satisfaction against the need for greater employee retention in a sector where staff turnover is common. Most restaurant tasks are divided broadly into front and back-of-house activities which are characterized by a wide range of different management styles and human resource strategies; back-of-house staffs are responsible for producing food, while front of house staffs serve it, and each activity demands different sets of skills and personality types. This study’s respondents belong to both the front and back-of-house. A total of 600 surveys were distributed to individual employees at 35 different large restaurants located in metropolitan areas across Mongolia. These restaurants were selected based on established personal relationships between one of the authors and the senior managers of the restaurants, and thus was well known to some employees. In Mongolia, having a personal relationship with key personnel of a company enhances collaboration with all levels of the organization. This is a similar to the Chinese guanxi culture. The manager of each restaurant wrote a memo to the employees and requested their cooperation. Employees were given assurance of confidentiality and allowed to respond to the survey anonymously during work hours. By the cutoff date for data collection, 431 usable surveys were received for a response rate of 71.8%.

Regarding the characteristics of the respondents, over two-quarters of the respondents (74.3%) were female and more than half of them were married (57.7%). About 64.6% had more than college/university level education, and the rest had at most a high school education. Respondents were spread across all age groups with 36.5% between the ages of 18 and 25, 48.2% between the ages of 26 and 35, and rest were 36 years and older. On average 63.4% of the respondents have worked at the restaurant for 3 years or more, and thus it is reasonable to assume that they are rich in experience within this sector. The respondents positions were split almost equally between front (58.5%) and back-of house (41.5%). In terms of the size of the restaurants, 75.2% of the respondents were from restaurants that had more than 11 employees; the average age of the restaurants was 6 years. A comparison of the sample profile to the company records indicated that the sample was representative of the population of front and back-of house employees.

Several methods were applied to evaluate response bias: Comparisons of early and late responses (first 150 versus last 150) across the study variables resulted in no significant differences (p > .05). After a comparison of employee responses for cases included in the final data set, excluding those that had missing representative restaurant data, the study variables revealed no significant differences (p > .05). Representative restaurant-provided performance data for employees who were included in the final data set compared with those for employees who were excluded because they failed to respond indicated that neither sales nor commission rates differed significantly across these two groups (p > .05). According to these analyses, response bias is not a major concern.

**Measurement**

After reviewing the relevant literature and conducting informal discussions with industry practitioners, we adapted most measures from previous literatures, while the rest were developed specifically for this study. English questionnaires were professionally translated into Mongolian and then back-translated to ensure conceptual equivalence. The questionnaire items were pretested to a sample of 200 employees who worked within the restaurant industry. On the basis of their responses, we revised a few questionnaire items to enhance clarity. Most of items were measured by a
Composition models define the relationships among the variables at different levels of analysis that concern fundamentally the same content but are qualitatively different. As a result, this study employed the referent-shift consensus composition model as we were interested in individual employees’ aggregate perception of the restaurant’s OCO. The OCO measure was specifically designed for the purpose of this referent shift, with the collective entity being the focal point. A five-item scale measuring OCO was adopted from Evans et al. [14]. It asked the employees to indicate their perceptions of their restaurants’ customer orientation strategy. Sample items read “My company’s business objectives are driven primarily by customer satisfaction” and “My company constantly monitors and assesses employee commitment to serving customers’ needs.” The Cronbach’s alpha was 0.79.

Control variables

Accounting for the heterogeneity of the sample, we controlled for gender, age, education, job tenure and job position. These variables have been found to distinguish employee performance [11]. We created dummy variables for gender, and measured age, education, job tenure, and job position on three to five-point scales.

Measurement model

We conducted a confirmatory factor analysis (CFA) to test the discriminant validity of the measures. Although the CFA chi-square statistic (214.253, d.f. = 109) was significant, an examination of the comparative fit index (CFI), root mean square error of approximation (RMSEA), and standard root mean square residual (SRMR) estimates (0.93, 0.07, and 0.04, respectively) suggested that the measurement model fit the data well: Values for the CFI that are above 0.90 and close to 0.95 are considered desirable, while RMSEA and SRMR estimates that are less than or equal to 0.08 are considered indicative of a good fit [22]. All factor loadings of the indicators to their respective latent constructs were significant. Moreover, all individual reliabilities were larger than 0.69, the highest composite reliability was 0.83, and the lowest average variance extracted was 0.53, providing evidence that all constructs possess adequate reliability and convergent validity [24-25]. In addition, all squared correlations between the latent constructs were smaller than the average variance extracted from the respective constructs, and further supported the measures’ discriminant validity [24].

Analytic approach

Because the theoretical model is multilevel and some of the data could vary across the 35 restaurants and among employee within restaurants, thus violating the assumption of independence, it was important to test for the suitability of the multilevel analysis. To determine whether a two-level approach was warranted, we applied hierarchical linear modeling (HLM) to examine intraclass correlation coefficients (ICCs) and corresponding design effects to ascertain the extent of systematic group level variance [26]. We assessed between-group variance in the

five-point Likert scale with endpoints of “strongly disagree” and “strongly agree”.

Individual-level variables

Employee customer orientation (ECO). We adapted the measure of employee’s customer-oriented behavior from Stock and Hoyer’s [13] study, and consisted of seven items that reflect the ability of the employee to help their customers by engaging in behaviors that increase customer satisfaction. Examples include behaviors such as trying to help to achieve the customer’s goals, discussing the customer’s needs, and trying to influence the customer with information rather than by pressure. Scale reliability based on Cronbach’s alpha was high (i.e. α = 0.80) and larger than the cut-off criterion of 0.7 recommended [22], indicating there was a high degree of internal consistency among the construct items.

Job demands. We measured job demands by two sub-scales, namely work overload and work-home interference with fourteen items adopted from Lewig et al. [16]. The 10 items to quantitatively measure work overload measures the degree to which an employee has to work fast and hard, has a great deal to do, and has too little time. A sample item is “My work requires me to work very hard.” Work-home interference is defined as a form of interrole conflict in which the role pressures from the work and family (home) domains are mutually incompatible in some respects, and was measured using four items. This scale was selected because it is sensitive to a broad range of personal and social concerns of both married and unmarried employees. Respondents were asked to indicate the level of applicability to them on a five-point Likert-scale, ranging from (1) “never” to (5) “always”. A sample item is “How often does the time you spend at work detract from your family or social life?” The internal consistency of the job demands scale was satisfactory, with a Cronbach’s alpha coefficient of 0.71.

Job resources. We derived two job resources dimensions – job control and social and supervisory support – using nine and six items respectively for a total of fifteen items. These items were borrowed from a scale that was developed and validated by Bakker et al. [2]. Job control refers to employees’ control regarding job content and the timing of work tasks. An example item is “The job allows the employee to make a lot of decisions on his own.” Social and supervisory support is defined as overall levels of helpful social interaction available on the job from coworkers and supervisors. A sample item reads “My boss is willing to listen to work related problems.” The Cronbach’s alpha coefficient for job resources was 0.79.

Job satisfaction. We used a five-item scale to measure employee job satisfaction, which was derived from Rich et al.’s [15] study. The scale assesses the work itself, pay and fringe benefits, the work-site’s physical surroundings, immediate supervisors and promotional opportunities. A sample item is “Overall, I am satisfied with my present job.” The alpha coefficient for this scale was 0.73.

Organizational-level variable

Organizational-level customer orientation

According to Chan [23], specifying the appropriate composition model is essential for multi-level research.
organization/unit-level OCO construct using a one-way analysis of variance (ANOVA). The ANOVA indicated significant between-group variance in OCO (F = 5.17, p < .01). The ICC1 calculated from the ANOVA was 0.35. This value is at the high end of what can be expected in applied research settings [27]. Together, these statistics show acceptable levels of within-group agreement and between-group variability in OCO as an organization/unit-level variable suggesting that a multilevel structure should not be ignored. Conceptually, HLM is a simultaneous two-step approach to modeling multilevel relationships, which we estimated with full maximum likelihood; it compares the model fits across nested models [28]. HLM partitioned the variance of individual-level outcomes into level 1 (i.e., individual-level) and level 2 (i.e., organizational-level) components and then regressed the level 1 variance component on individual-level predictors and the level 2 variance component on organizational-level predictors. We then tested cross-level interactions by regressing level 1 slopes (i.e., relationships between level 1 predictors and outcomes) onto level 2 predictors. Level 1 variables included controls, ECO, job resources, job demands, and job satisfaction, and the level 2 variable consisted of the OCO variable.

First, we specified a null model (Model 1), in which there were no individual and organizational level predictors included. This enabled us to test whether there was significant variation in job satisfaction, a necessary precondition for supporting our hypotheses. We then specified a model (Model 2), in which we added individual level variables and predictors. This enabled us to evaluate our first set of hypotheses concerning the effects of individual-level determinants on job satisfaction. Finally, we specified a full model (Model 3) in which we added organizational level predictor of the individual-level slopes. This enabled us to assess whether cross-level interactions provided a significantly incremental prediction of job satisfaction [28].

RESULTS

Main effects

Table 1 summarizes the results of the HLM analyses for the hypotheses (1 through 6). The control variables (employees’ gender, age, education, tenure and income) and the individual and organizational-level main effects of OCO were included in all analyses. We first tested whether ECO is positively related to job satisfaction (Hypothesis 1), and found that it has a positive influence ($\beta = 0.16$, p < .05). Thus Hypothesis 1 is supported. We further found that employee job resources are positively related to job satisfaction, with a significant and positive effect ($\beta = 0.56$, p < .01), supporting Hypothesis 2. However, we found no evidence in support of Hypothesis 3, which predicts that employee job demands have a significant and negative effect on job satisfaction. Lastly, Model 3 shows that among the individual level control variables, only employee age ($\beta = 0.06$, p < .01) and education ($\beta = 0.12$, p < .01) were significant predictors of job satisfaction.

Moderating effects

In Hypotheses 4 through 6, we predicted various interaction effects between individual differences and OCO. The findings indicate that while OCO does not moderate the relationship between ECO and job satisfaction, it does moderate the relationship between job demands and job satisfaction and job resources and job satisfaction; the interaction of job demands and OCO was significant and negative ($\beta = -0.63$, p < .01), and the interaction of job resources and OCO was significant and positive ($\beta = 0.80$, p < .01). Thus while Hypothesis 4 is not supported, Hypotheses 5 and 6 are.

| Table 1. Hierarchical linear modeling results for job satisfaction |
|-----------------------------------|-----------------|-----------------|-----------------|
| Predictor                          | Model 1         | Model 2         | Model 3         |
| Intercept                          | 4.16 (0.05)**   | 3.84 (0.04)**   | 4.19 (0.06)**   |
| Main effects                       |                 |                 |                 |
| ECO                                | 0.16 (0.09)*    | 0.16 (0.07)*    |                 |
| JR                                 | 0.56 (0.09)**   | 0.55 (0.07)**   |                 |
| JD                                 | -0.08 (0.07)    | -0.09 (0.06)    |                 |
| Moderating effects                 |                 |                 |                 |
| ECO x OCO                          | 0.49 (0.40)     |                 |                 |
| JR x OCO                           | 0.80 (0.41)*    |                 |                 |
| JD x OCO                           | -0.63 (0.33)*   |                 |                 |
| Control variables                  |                 |                 |                 |
| Gender                             | 0.06 (0.07)     | 0.05 (0.07)     |                 |
| Age                                | 0.07 (0.04)*    | 0.06 (0.05)*    |                 |
| Education                          | 0.14 (0.06)**   | 0.12 (0.07)*    |                 |
| Tenure                             | 0.02 (0.02)     | 0.02 (0.05)     |                 |
| Income                             | 0.00 (0.04)     | 0.00 (0.04)     |                 |
| 2-log likelihood                   | -3.38352        | -3.062952       | -3.015327       |
| Incremental chi-square             | 35.26831        | 42.94142        | 46.07659        |
| Degree of freedom                  | 21              | 21              | 20              |
| P-value                            | .026            | .002            | .001            |

**. Correlation is significant at the .01 level; *. Correlation is significant at the .05 level (two-tailed).

DISCUSSION AND CONCLUSION

Our study used a cross-level approach to examine how OCO influences the impact individual differences have on job satisfaction, as hypothesized in customer orientation and JD-R model research. In order to do this, we first provided additional insights regarding the nature of the effects of ECO and the JD-R model on job satisfaction. We further attributed the weak role organizational context variables play in explaining job satisfaction to the nature of the basic individual personality traits and stress variables used in prior studies. Thus, in this study, we conceptually incorporated OCO in our framework and empirically demonstrated its moderating role in the individual’s job satisfaction process.

Our first research question asked how individual differences (ECO and JD-R) influence job satisfaction. First, ECO was found to have a significant and positive influence.
This supports previous studies which have found that the motivation an employee has to engage in a customer-oriented manner will be enhanced when they receive both intrinsic and extrinsic rewards in exchange for effort investment [11]. Furthermore, in contexts in which the primary task is the serving of customer needs, customer-oriented employees fit the service setting better than employees who have a lower customer orientation because they are predisposed to enjoy the work of serving customers [5]. Therefore, employees with higher levels of ECO will be more satisfied with their jobs than will employees who have less customer orientation.

In support of the JD-R model the findings indicated that the presence of job resources (as enriching and motivational job characteristics) exerts a significant and positive effect on job satisfaction. Employees who are surrounded by resourceful job characteristics are more likely to experience a general feeling of psychological freedom (i.e., autonomy), interpersonal connectedness (i.e., belongingness), and effectiveness (i.e., competence), which in turn explains why they feel more satisfied in their jobs [12]. However, the existence of job demands (as energy-depleting job characteristics) was found to have no significant negative effect on job satisfaction. This is in line with findings of some studies, as the effects of job demands have been found to vary in service contexts. An explanation is that perhaps job demands contain an important physical component, which might directly contribute to the emergence of emotional exhaustion without interfering with job satisfaction [30]. This is in accordance with Broeck et al. [31] who find that satisfaction is a process capturing individuals’ psychological energy and is unlikely to account for the physical energetic component of job demands. A possible second explanation is that job demands might have a curvilinear relationship with employees’ motivation and energy level. That is, whereas high levels of job demands might be energy depleting, low to moderate levels might stimulate employee satisfaction [31]. Further research is needed to examine whether this correlational pattern is due to specific characteristics of this study and to disentangle the moderate relationship between job demands and job satisfaction in general.

Our second question pertained to the influence of OCO as a moderator on the impact of individual differences on job satisfaction. The results partially supported our hypotheses that the interaction between OCO and ECO on job satisfaction is positive, but they were not statistically significant. The interaction between OCO and job resources (job demands) was significantly positive (negative) in their effect on job satisfaction, and thus these hypotheses were supported. In support of recent evidence that suggests ECO is part of an organizational climate and culture [32]. When employees perceive a psychological climate of customer orientation, they should feel that the organization, by focusing on the customer, is in line with their own personal goals. This congruence should enhance feelings of job satisfaction and likewise motivate them to perform [14]. Thus, high levels of ECO is a critical part of an organizational climate; it would also represent an organization-level customer orientation.

Consistent with the JD-R model, this study proposes that the impact job demands and resources have on job satisfaction may also be affected by employees’ perceptions of the working environment. Thus, properties of the work environment, as well as characteristics of the individual, can buffer the effects of job demands. The buffering variable can reduce the tendency of organizational properties to generate specific job demands, alter the perceptions and cognitions evoked by such stressors, moderate responses that follow the appraisal process, or reduce the health-damaging consequences of such responses [3]. In this study, although the job demands construct is not found to have a significant direct effect on job satisfaction, its interaction with OCO is found to be significant and negative, suggesting that the job satisfaction of employees with high OCO declines faster as job demands increase. OCO therefore plays an important role in delivering higher levels of satisfaction when the perception of job demands is significantly reduced. Next, in line with the motivational process of the JD-R model [16], OCO was found to moderate the relationship between job resources and job satisfaction. This implies that when employees feel supported by their peers and have a sense of autonomy over their work, they are likely to feel satisfied in their jobs. The existence of resources makes employees feel appreciated by the organization and the community, as well as connected to the organization’s customer oriented focus. Furthermore, job resources are more likely to produce a high level of job satisfaction under high OCO conditions than under low OCO conditions. Overall we found that the integration of the concept of OCO in the JD-R model adds to its predictive validity, and seems to be highly relevant for the workforce.

Managerial implications

The findings suggest that managers must recognize several important factors when they evaluate their employees’ customer-oriented behavior, job demands, and resources. We further believe that these implications are applicable to the disseminations of a firms’ customer orientation as well. As customer orientation is found to be an important indicator of job satisfaction for employees, and employees generate goods and services for the end customer, ECO is crucial to providing customer satisfaction. Thus, ECO may lead to competitive advantages for the organization through exploring and exploiting a trusted and committed relationship between the organization and its customers. This is important, as many businesses are particularly dependent on the development of long term relationships with their customers. It may further be argued that ECO takes on added importance in service organizations, as customers often do not have tangible cues with which to evaluate the service offering. Thus, from a managerial perspective, an organization should strive to develop and enhance individual levels of customer orientation. Without an emphasis on satisfying the requirements of employees, superior value will not be provided at every stage of the value chain, and thus the end customer will not receive an optimal product or service [32].

Second, in relation to the JD-R model, job resources were found to directly influence job satisfaction, while it was found that job demands do not. Thus, management may attempt to change employees’ perceptions of job demands and concurrently make improvements in job resources such as providing increased supervisory support, training, and reward mechanisms. However, it is important for restaurants to find a balance
between providing job resources to employees and the cost of providing these. Thus, managers should develop and encourage employees’ abilities to work under job resource constraints in order to improve both the efficiency and effectiveness of operations as well as employee job satisfaction.

Third, the findings that show the OCO climate plays a critical role in reducing the dysfunctional effects of job demands and enhancing the motivational effects of job resources is important for management: They should focus efforts on improving OCO while at the same time reducing perceived severity of job demands and increasing job resources or the efficiency of their use in order to improve employee job satisfaction. This finding can also be used by management in the employment recruitment and selection process. By first conducting an assessment of the level of OCO, if it is found to be strong, a restaurant can greatly benefit from hiring individuals who are highly customer oriented, as they would be expected to respond more favorably to the job than employees who are less customer oriented. This is because those with higher ECO levels are expected to follow display rules with relative ease, are resistant to burnout, and their self-presentations do not need to rely on surface or deep acting. In restaurants with high OCO, such authentic displays are consistent with organizational as well as customer expectations, and ultimately result in customer satisfaction and improved organizational outcomes.

Finally, this study provides additional support through the findings related to the control variables: age and education were found to be important demographic variables in the job satisfaction model; these are thus important as they provide linkages between individual experience and personal accumulated knowledge. Thus, based on the findings of the relationship between employee demographics and their job satisfaction, managers can identify attitudinal and behavioral differences among employees, and some form of internal fit between the demographics characteristics of employees and policies and practices within organizations may be required.

REFERENCES


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IMPACTS OF CHANGE ON ADMINISTRATIVE STAFFS IN UNIVERSITIES

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ABSTRACT

The rapid change of the business environment has pushed the universities to cope with unprecedented challenges. The government-funded universities are no longer a "shelter" for employees. In particular, the administrative staffs that provide front-line services to the universities may be more vulnerable, because they appear not to be "academic" for the academic institutions. As such, administrative staffs may be more likely to suffer from the organizational change, and they may accordingly alter their working attitude and behavior. The purpose of this study is to examine the negative impact of change on these individuals' attitude and behavior at work.

Keywords: Organizational change, perceived organizational support, perceived supervisory support, psychological contract, job satisfaction.

INTRODUCTION

Organizational change has become a common practice nowadays. The rapid, dynamic, and continuous change of the business environments has forced organizations to cope with a higher degree of challenges [1]. In the context of globalization, local universities can no longer be confined to act local but also forced to go global to compete (or even survive) in the highly competitive global environment. It has become prevalent nowadays that the local universities adopt such entry modes as countertrades (e.g., student exchange), strategic alliances (e.g., Strategic Engineering School Alliance formed by HKUST and UPenn), and joint ventures (e.g., China Europe International Business School, aka CEIBS) among universities across the international business arenas. In response to the environmental changes and the fierce competitors all over the world, organizational changes in universities have become unavoidable [10].

Just like those elsewhere, universities in Hong Kong have been commonly considered nonprofit organizations. In reality, however, these institutions nowadays have to make 'profits' through different ways, such as fund raising, self-financed academic programs, entrepreneurial partnership, etc. In the past decade, universities funded by the University Grants Committee (UGC) of the Hong Kong Special Administrative Region have suffered from continuous fund cutting due to burgeoning budget deficit by the government. Nevertheless, they have been forced to cope with increased pressures from local and international competitors. In response to the strong demand for becoming global- and knowledge-based institutions [78], the once relatively bureaucratic, government-funded universities in Hong Kong have been urged to phase out the traditional forms of educational governance and adopted new managerial forms and practices that have been commonly used at the private or corporate organizations [44]. These institutions have been aspiring for a leading position through market-conscious operations and customer-oriented services or striving for maximizing their 'profits' from self-financed programs. For instance, they have attempted to establish collaborative partnerships from various aspects with tertiary educational institutions all over the world, or develop business links with profit making MNCs from different industries. In other words, the government-funded (i.e., University Grants Committee or UGC-funded) universities in Hong Kong have no longer been a "shelter" for employees. Furthermore, the administrative employees that provide front-line services to universities may be more vulnerable, because these employees appear not to be as "academic" as the academic staff that may be regarded as more "necessary" for the academic purposes for academic institutions. For example, City University of Hong Kong, one of the eight UGC-funded universities, allocated about 65% of its resources to support research and teaching activities, while only some 30% was used to support administrative and supportive services in 2001, and an annual budget cut about 3% had been exercised for several consecutive years [11]. The administrative employees may be more likely to suffer from the tremendous change, and they may subtly alter their working attitude and behavior in response to the change.

Although change appears to be necessary for organizations to succeed, or survive, in the turbulent business environments, organizational change inevitably interrupts social and obligated relationship between organizations and their employees [2]. Such "side effects" do not only impinge on work attitude and behavior of employees but also weaken the performance of organizations. Research found that organizational change affected employees' work attitude and behavior, such as job satisfaction [68], job security [4], organizational loyalty [52], and organizational commitment [32]. It also affected employees' job performance [70] and productivity [12]. These impacts of organizational change on universities, in particular to the administrative employees, have unavoidably affected the employer-employee relationship and, consequently, reshaped employees' work attitude and behavior.

In the extant literature, however, the impacts of organizational change on employees' work attitudes and behaviors in nonprofit organizations in particular those in government-funded universities have not been fully investigated. Certain underdeveloped research perspectives are thus worth noting. First, from a theoretical perspective, although research has noticed that organizational change may have negative impacts on employees' work attitude and

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behavior [39] [62] [65], there has been little attention to the influences of employees' perception of support from their organizations and superiors and the fulfillment of psychological contract on organizations during the process of organizational change. Second, from a cultural perspective, the majority of the organizational change research has been conducted in the western contexts [36] [50] [73], whereas research has shown that there are cultural variations on the psychological reactions and behavioral outcomes of the employees at work [35] [69]. For example, [38] found that employees' fulfillment of psychological contract was attributed to the differences between western and eastern cultures. As such, the external validity of the findings, predominantly conducted in the western context, on the effects of organizational change on work outcomes is subject to verification. Third, from a sampling perspective, the extant literature has primarily focused on managerial positions in the commercial firms [73], while the research on the administrative employees in nonprofit organizations has been minimal. However, these frontline employees are likely to be the first target of people affected by organizational change, and their work attitude and behavior, to a certain extent, affects organizational performance. To bridge the knowledge gap, this study attempts to develop and test a theoretical model linking between organizational change and work outcomes to a sample of the administrative employees of the government-funded universities in Hong Kong.

THEORETICAL MODEL

Two theories underlie how employees' work attitude and behavior may be restored in the process of organizational change, namely organizational support theory and psychological contract theory. Organizational support theory (OST) maintains a global belief of employees concerning the extent to which the organization cares about them and values their contributions to the organization. It holds that employees' perceived organizational support produces a felt obligation to care about the organization's welfare and help the organization to achieve its goals [55] [64]. Perceived organizational support captures an individual's perception concerning the degree to which an organization values their contributions and cares about their well-being [16] and the level of the organization's commitment to them [55] [77]. Perceived organizational support focuses on the organizational treatment perceived by the employees, regardless of whether the treatment is explicitly or implicitly promised [13].

Psychological contract theory is an extension from social exchange theory and the norm of reciprocity, which becomes the focal point of the researchers studying the changing nature of the employment relationship and associated attitudinal and behavioral reactions of the employees. Psychological contract is defined as an individual's belief regarding the terms and conditions of an exchange relationship between that person with another party [60]. It implicitly relates to the mutual obligations and expectations that exist between employers and employees [31] [58]. In light of the obligated exchange on socialization, employees strategically and rationally interact for initiating, strengthening, maintaining relationships with their organizations [15]. As psychological contract is inherently perceptual, one party's understanding of the contract may not necessarily be shared by the other [57].

Drawing upon the theories of organizational support and psychological contract, the theoretical model of this study was developed. The variables perceived organizational support, perceived supervisory support, and psychological contract were hypothesized as significant mediators that would alter the directions of the relationship between organizational change and work outcomes. In particular, the breach of psychological contract due to organizational change was reversely mediated by perceived organizational support and perceived supervisory support. In turn, the effects of perceived organizational support and perceived supervisory support on various work attitude and behavior, namely job satisfaction, job security, job stress, organizational commitment, organizational loyalty, and turnover intention, are mediated by employees' psychological contract. The model is depicted in Figure 1.

Organizational Change and Perceived Organizational Support

In the literature, researchers found that employees' perception of organizational support was negatively related to organizational change [2] [56]. Employees formed favorable perception to which organizations valued their contributions and cared about their well-being [15]. In contrast, organizations downplaying employees' contributions and well-being would lessen their perceived obligations to the employers. Likewise, based on the norm of reciprocity, employees would respond negatively to perceived unfavorable treatment from the employers, and consequently, the employer-employee relationship would be negatively affected. As organizational change implies that organizations are likely to protect employers' own benefits at the expenses of those of the employees, employees may perceive it as an unfavorable treatment and as a violation of the norm of reciprocity by single side of the employers. Thus, we expect:

Hypothesis 1a. Organizational change will be negatively related to perceived organizational support of employees.

Organizational Change and Perceived Supervisory Support

Based on social exchange theory and the reciprocal obligation, employees may also develop a perception of supervisory support concerning the degree to which superiors value their contributions and care about their well-being [36] [49]. In fact, supervisors have long been recognized to play an important part in developing roles and expectations of employees [23]. Previous studies demonstrated that organizational change was closely related to supervisory support perceived by the employees. As supervisors structured work environment and provided information and feedback to employees about the support of the broader organization for change, their behaviors were likely to be interpreted as representative of the broader organizational processes [25]. Therefore, the violation of the norm of reciprocity by the organizations may also be
attributed to their supervisors who have not stood up for their own benefits. Thus, we expect:

**Hypothesis 1b.** Organizational change will be negatively related to perceived supervisory support of employees.

**Perceived Organizational Support and Psychological Contract**

Both perceived organizational support and psychological contract stress the social exchange process in the establishment and maintenance of the employer-employee relationship, with an emphasis on organizations' attainment of favorable outcomes through the favorable treatment to the employees [2]. Researchers indicated that the favorable treatment made to employees resulting in the fulfillment of psychological contract might also increase employees' perceived organizational support. In contrast, the organizations that failed to provide a felt obligation to the employees would be viewed as a breach in psychological contract fulfillment, which might lead to erosion of the exchange foundation of the employer-employee relationship [57] [60]. Thus, we expect:

**Hypothesis 2a.** Perceived organizational support of employees will be positively related to their psychological contract.

**Perceived Supervisory Support and Psychological Contract**

Other than the perception of organizational support, perceived supervisory support also plays a key role on the social relationship in the organizations. The employees generate a felt obligation to positively achieve desired attitudes and performance in response to supervisory support [20]. According to psychological contract theory, employees' negative perception of supervisory support may damage the supervisor-employee relationship, following by the breach of psychological contract on the supervisor-employee relationship. Thus, we expect:

**Hypothesis 2b.** Perceived supervisory support of employees will be positively related to their psychological contract.

**Psychological Contract and Work Outcomes**

Psychological contract focuses on the discrepancy between what was promised and what have fulfilled, providing the basis on which employees reciprocate [13]. Previous research demonstrated that violations of psychological contract were associated with a variety of negative work outcomes [58] [73]. In the following, the fulfillment of psychological contract was hypothesized to be positively related to several work outcomes.

Job satisfaction was defined as an internal state that was expressed by affectively and/or cognitively evaluating one's job with some degree of favor [6]. In other words, job satisfaction was individuals' general attitude toward their job [45]. Job satisfaction consisted of multi-dimensional constructs such as satisfaction with supervision at work, work itself, pay and conditions, appraisal, promotion practices, and co-workers [29]. When employees presented a high level of job satisfaction, they may have positive attitude towards their jobs. For example, the employees who were more satisfied with their jobs were also less [28] and less likely to leave [9]. The widespread organizational change has resulted in employees' disillusion toward their organizations. When employees perceived that their organizations had failed to fulfill their promises or obligations, a breach of psychological contract emerged and led to a sense of unmet expectations toward the organizations. Previous research suggested that the discrepancy between promised and received outcomes was likely to lead to the feelings of inequity and, subsequently, job dissatisfaction [37] [76]. In other words, psychological contract of employees was a critical indicator to job satisfaction. Thus, we expect:

**Hypothesis 3a.** Fulfillment of psychological contract will be positively related to job satisfaction of employees.

Researchers theorized that one of the most prevalent consequences of organizational change was job security [46]. Over the past decade, a number of organizations that have encountered dramatic and unappeasable wave of organizational change have increasingly found difficulty in fulfilling the traditional expectation of providing long-term employment to their employees, even if some organizations understood that this would damage their reciprocal...
obligations on the employees. As such, the employees who had assumed that their positions were secured had to deal with potential or actual job loss [43] [59]. When obligations associated with the psychological contract were not fulfilled, the problem of job security also reflected a negative message to the employees [16]. Empirical studies also supported that employees' fulfillment of psychological contract was positively associated to job security [1] [4]. Thus, we expect:

**Hypothesis 3b.** Fulfillment of psychological contract will be positively related to job security of employees.

Organizational loyalty referred to one's specific psychological commitment to the organizations [52]. Employees who were loyal to their organizations were motivated to work hard and were willing to stay with the organizations. Since organizational changes constantly increased unmet expectations to the employees [57] [73], such discrepancies on employer-employee relationship inevitably precipitated the breach of employees' psychological contract and thus the decrease in organizational loyalty. [58] found that psychological contract breach was negatively associated with employee loyalty to their organizations. Thus, we expect:

**Hypothesis 3c.** Fulfillment of psychological contract will be positively related to organizational loyalty of employees.

Organizational commitment was defined as the relative strength of an individual's involvement in a particular organization characterized by strong acceptance or a belief in an organization's goals and values, willingness to exert effort on behalf of the organization, and a strong desire to maintain membership of the organization [48]. Organizational commitment could thus be seen as the extent to which employees identified with their organizations and managerial goals, showed a willingness to invest effort, participated in decision making, and internalized managerial values [51]. Organizational commitment was the driving force behind an organization's performance [67]. Historically, guarantee of life-long employment by the organizations being a crucial practice of fostering strong commitment of employee to the organization was implicit in the psychological contract between organizations and employees [45]. Organizational change could influence commitment through its impacts on the psychological contract that the employee had toward the organizations [61]. Thus, we expect:

**Hypothesis 3d.** Fulfillment of psychological contract will be positively related to organizational commitment of employees.

Previous studies have long indicated that organizational change had significantly negative impacts on changing psychological contract of employees to their employers [26] [65]. An important contribution of the current study was to argue that these previous studies have omitted some essential variables in describing the relationship between organizational change and psychological contract. One of these variables might be perceived organizational support. As mentioned before, according to psychological contract theory, when the employees believed that the organizations were unable to fulfill their promises or obligations, a breach of psychological contract would typically create the perception of an imbalance in the social exchange relationship, and organizational change often facilitated such an imbalance and inequity in the organizations. However, according to organizational support theory, when employees' also believed that the organizations valued their contributions and cared about their well-being [16] during the process of organizational change, the violation of psychological change would be minimal or even disappeared. Thus, we expect:

**Hypothesis 4a.** Perceived organizational support will be reversely mediated the negative relationship between organizational change and psychological contract of employees.

Similar to the mediating effect of perceived organizational support, the current study also proposed that perceived supervisory support had the same mediated effect on the relationship between organizational change and psychological contract. Based on the social support relationship, the source of social support in the work environment, such as a supervisor, could counter-balance and buffer the potentially negative effects of work demands for employees [14] [41]. Thus, we expect:

**Hypothesis 4b.** Perceived supervisory support will be reversely mediated the negative relationship between organizational change and psychological contract of employees.

Although research indicated that perceived organizational support and perceived supervisory support were positively related to a variety of work outcomes [17] [27] [63], the mediating role of psychological contract on the relationship has not been fully investigated. Based on the assumptions of the significant relationships between perceived organizational support and the fulfillment of psychological contract [47] [61], and prior research consistently suggesting that psychological contract breach negatively influenced employees' attitudes and behaviors [57] [58], psychological contract was hypothesized to be a positive mediator of perceived organizational support and perceived supervisory support on several work outcomes. Thus, we expect:

**Hypothesis 5a.** Psychological contract will be a positive mediator of the relationship between perceived organizational support and (i) job satisfaction, (ii) job security, (iii) organizational commitment, and (iv) organizational loyalty and a negative mediator on the relationship between perceived organizational support and (vi) job stress and (vi) turnover intention.

**Hypothesis 5b.** Psychological contract will be a positive mediator on the relationship between perceived supervisory support and (i) job satisfaction, (ii) job security, (iii) organizational commitment, and (iv) organizational loyalty and a negative mediator on the relationship between perceived supervisory support and (vi) job stress and (vi) turnover intention.
METHODS

Subjects

The administrative employees (including administrative, executive, clerical, and technical positions, etc.) from the government-funded universities were targeted. A total of 3,516 mail questionnaires were sent to all of the full-time administrative employees (including tenured-based and contract-based employees) whose personal information could be searched from the universities' official websites. The usable returned questionnaires were 1,108, with a response rate of 31.51%, which was relatively high in Hong Kong [30] [71]. In the sample, 33% of the respondents were male and 67% were female. Approximately 40% of the respondents aged between 31 and 40. Besides, about 60% of the respondents were married.

The questionnaire items were originally in English. As the first language was Chinese in Hong Kong, it would be easier for the respondents to understand and complete the survey. Therefore, all measurement items were translated into Chinese. To ensure accuracy and correctness, the Chinese version was back translated into English [7]. Equivalence was found between two English versions. The questionnaires were sent by mail, enclosed with stamped return envelopes. The participants were assured of confidentiality.

Measures

Organizational change was measured using 6-item scale extracted from revised 11 of total 14 different types of organizational change developed by [53]. The respondents were requested to indicate whether each selected item was a characteristic reflecting their real situation. Response option was a five-point scale. Two sample items were: (1) Reductions in force – layoffs, firings, downsizings, involuntary separations, and (2) Reorganizations of personnel or operations – changes in divisional structures, reporting relationships. Cronbach's alpha of .71 was obtained for this measure.

Perceived organizational support was measured using [16] instrument. Over a decade later, [77] used a shortened 9-item version of the Survey of Perceived Organizational Support (SPOS), loaded highest in [16]'s factor analysis. This shortened version of the SPOS was used in previous research [16]. Some items denoted with (R) were reverse scored. Responses were obtained on a 5-point Likert-type scale where 1, strongly disagree, and 5, strongly agree. Two sample items from the scale were: (1) The organization shows little concern for me (R), and (2) The organization takes pride in my accomplishments at work. Cronbach's alpha of .86 was obtained for this measure.

Perceived supervisory support was measured using [24]'s 9-item scale. This instrument was used to assess the extent of perceptions of supervisory support received by employees in their job. Responses were obtained using a 5-point Likert scale, where 1, strongly disagree and 5, strongly agree. Two sample items from the scale were: (1) My supervisor takes the time to learn about my career goals and aspirations, and (2) My supervisor assigns me special projects that increase my visibility in the organization. Cronbach's alpha of .92 was obtained for this measure.

Psychological contract of employees were measured using [73]'s 16-item scale. These 16 elements tapped the typical dimensions to test the employment relationship. Responses ranged from 1, 'received much more than promised'; 2, 'Received more than promised'; 3, Received about the same as promised'; 4, 'Received less than promised'; and 5, 'received much less than promised'. A sample item from the scale was: Job challenge and excitement. Cronbach's alpha of .88 was obtained for this measure.

Employee’s job satisfaction was measured using [42]'s 3-item scale. Within which, an item denoted with (R) were reverse scored. The scale was used to test whether employee was satisfied with his or her job. Responses were obtained using a 5-point Likert-type scale anchored by 1, strongly disagree, 5, strongly agree. A sample item is: In general, I like working here. Cronbach's alpha was .83 for this measure.

Job security, an employee's associated work outcome, was measured using [34] 3-item scale. The items used to address the level of certainty an employee was about keeping his or her job. Responses were obtained on a 5-point Likert scale anchored by 1, strongly disagree and 5, strongly agree. A sample item is: I am certain I will not be laid off in the next six month. Cronbach's alpha of .77 was obtained for this measure.

Organizational loyalty was measured using [66]'s instrument. Four items were used to assess employee's loyalty to organization through a job taking in an organization. The response format was a 5-choice Likert scale with anchors (1) strongly disagree through (5) strongly agree. Two sample items were: (1) If I had to choose all over again, I would take a job with this company, and (2) I would be willing to spend the rest of my career working for this company. Cronbach's alpha for this measure was .87.

Organizational commitment was measured using [40]'s 6-item scale. Within which, two items denoted with (R) were reverse scored. The scale was adopted to address the degree of the employee's commitment to their serving organization. Responses were obtained on a 5-point Likert-scale anchored by 1, strongly disagree, and 5, strongly agree. Two sample items were: (1) I am willing to work harder than I have to in order to help this organization succeed, and (2) I would turn down another job for more pay in order to stay with this organization. Cronbach's alpha for this measure was .82.

The following control variables were used. The demographic variables included as controls were age, educational level, sex, marital status, number of children, monthly salary range (HK$), and years of service. Age was collected in 10-year blocks by a one-item self-report measure, which consisted of five categories: (1) 20 or below, (2) 21 to 30, (3) 31 to 40, (4) 41 to 50, and (5) 51 or above. Educational level consisted of four categories: (1) primary level, (2) secondary level, (3) undergraduate degree, and (4) postgraduate degree. Gender was measured by nominal scale, which was divided into two categories: (1) male and (2) female. Martial status was measured by nominal scale, which was divided into two...
categories: (1) married and (2) single. Number of children was collected by a one-item self-report ratio scale. Monthly income was measured by a one-item self-report measure, which consisted of six categories: (1) less than HK$10,000, (2) HK$10,001 to HK$15,000, (3) HK$15,001 to HK$20,000, (4) HK$20,001 to HK$25,000, (5) HK$25,001 to HK$30,000, and (6) HK$30,001 or above. Years of service in tertiary educational institution was measured by a one-item self-report measure, which consisted of six categories: (1) less than 1 year, (2) 1 to 5 years, (3) 6 to 10 years, (4) 11 to 15 years, (5) 16 to 20 years, and (6) 20 years or above.

Data Analysis

The data were analyzed by hierarchical multiple regressions using SPSS 14.0. For all regression equations, control variables were entered first, followed by the relevant independent variables or/and mediating variables. For testing the mediating effects, the analytical method recommended by [3] was adopted, which was described in the results chapter below.

RESULTS

Descriptive Statistics

Table 1 presented the means, standard deviations, correlations, and Cronbach's alphas for all studied variables. The internal reliabilities of the instruments were generally good, with alphas ranged from .71 (organizational change) to .92 (perceived supervisory support). The results showed that the participants encountered a considerable level of organizational change ($M=3.54$), consisted of significant cutbacks in operations, reductions in size, voluntary terminations, early retirement, reorganizations of personnel, attempted takeovers or merger, and rapid growth. Compared to organizational change, the means of perceived organizational support ($M=2.85$) and perceived supervisory support ($M=3.03$) were somewhat lower, and perceived organizational support was even below average, implying that the supports perceived by the supporting staff in tertiary educational institutions in Hong Kong were low relative to the changes, and the employees' perception of organizational support appeared to be low. Furthermore, their perception of supervisory support was a little bit higher than that of organizational support, indicating that the employees perceived less support from the organization relative to their supervisors during the changes. One explanation was that the supporting staff understood that their supervisors had less support from the organization relative to their supervisors, thus the employees perceived less support from the organization relative to their supervisors during the changes. One explanation was that the supporting staff understood that their supervisors had less support from the organization relative to their supervisors, thus the employees perceived less support from the organization relative to their supervisors during the changes.

The four work outcomes were all above average. Among them, the highest mean was job satisfaction ($M=3.53$). Since organizational change had been implemented everywhere, the problems caused by organizational change in the universities were not necessarily worse that the works outside the academic venues.

Testing for Direct Effects

Hypotheses 1a-b, 2a-b, and 3a-d were to test the direct effects of organizational change on perceived organizational support and perceived supervisory support, the direct effects of perceived organizational support and perceived supervisory support on psychological contract, and the direct effects of psychological contract on several work outcomes.

For Hypothesis 1a, as reported in Table 2, the results of Model 1 showed that organizational change was negatively related to perceived organizational support of employees ($\beta=-.23, p<.001$), indicating that organizational change did have negative effects on employees' perception of organizational support. Thus, Hypothesis 1a was supported. Likewise, for Hypothesis 1b, as reported in Table 2, the results of Model 2 demonstrated that organizational change was also negatively related to perceived supervisory support of employees ($\beta=-.14, p<.001$). Hypothesis 1b was supported.

Hypotheses 2a and 2b examined the effects of perceived organizational support and perceived supervisory support of employees on their fulfillment of psychological contract. As shown in Table 2 (Model 3), perceived organizational support was positively related to their fulfillment of psychological contract ($\beta=.69, p<.001$). In Table 2 (Model 4), the results also showed that perceived supervisory support was positively related to their fulfillment of psychological contract ($\beta=.63, p<.001$). Thus, both Hypotheses 2a and 2b were substantiated.

For Hypotheses 3a to 3d, the relationships between psychological contract and various work outcomes were investigated. As expected, in Table 3, psychological contract had significantly positive effects on job satisfaction ($\beta=.50, p<.001$), job security ($\beta=.35, p<.001$), organizational loyalty ($\beta=.56, p<.001$), and organizational commitment ($\beta=.51, p<.001$). Thus, Hypothesis 3a to 3d were all supported and at the right direction.

Testing for Mediating Effects

Hypotheses 4a-b and 5a-b were to test the mediating effects of perceived organizational support, perceived supervisory support, and psychological contract on the relationships between organizational change and various work outcomes. To test the mediating regressions, the procedure described by [3] were used. According to [3], four steps were needed to establish the mediating relationship. First, the independent variable must be related to the dependent variable. Second, the independent variable must be related to the mediating variable. Third, with the independent variable controlled, the mediating variable must be related to the dependent variable. Fourth, to establish that the mediating variables completely or partially mediated the relationship between the independent variable and the dependent variable, the effect of independent variable on dependent variable, controlling for the mediating variable, must be eliminated or reduced.

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Hypothesis 4a predicted that perceived organizational support was inversely mediated the negative relationship between organizational change and psychological contract of employees. As shown in Table 2, first, in Model 3, organizational change (independent variable) was negatively related to psychological contract (dependent variable) ($\beta=-.21, p<.001$). Second, in Model 1, organizational change (independent variable) was negatively related to perceived organizational support (mediating variable) ($\beta=-.23, p<.001$). Third, in Model 6, perceived organizational support (mediating variable) was positively related to psychological contract (dependent variable) ($\beta=.68, p<.001$), after organizational change (independent variable) was controlled. Fourth, in Model 6, the negative effect of organizational change (independent variable) on psychological contract (dependent variable) was substantially reduced ($\beta=-.05, p<.001$), after perceived organizational support (mediating variable) was controlled. The results revealed that perceived organizational support significantly mediated the relationship between organizational change and psychological contract; it also reversed the direction from negative to positive effect. It indicated that organizational change might lead to a breach in employees' psychological contract unless the employees perceived support from their organizations. Thus, Hypothesis 4a was supported.

Similarly, Hypothesis 4b predicted that perceived supervisory support was inversely mediated the negative relationship between organizational change and psychological contract of employees. First, same as Hypothesis 4a, organizational change was negatively related to psychological contract (Model 5). Second, in Model 2, organizational change was negatively related to perceived supervisory support ($\beta=-.14, p<.001$). Third, in Model 7, perceived supervisory support was positively related to psychological contract (Model 1). Fourth, in Model 7, the negative effect of organizational change on psychological contract was substantially reduced ($\beta=-.12, p<.001$), after perceived supervisory support was controlled. Thus, Hypothesis 4b was also supported.
TABLE 2. REGRESSION RESULTS FOR THE DIRECT AND MEDIATING EFFECTS

<table>
<thead>
<tr>
<th>Measure</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
<th>Model 6</th>
<th>Model 7</th>
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<td>.61 ***</td>
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<tr>
<td>R²</td>
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<td>.43 ***</td>
<td></td>
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<td>Adjusted R²</td>
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Model 1=perceived organizational support, Model 2=perceived supervisory, Models 3 to 7=psychological contract
* p<.05 ** p<.01 *** p<.001

TABLE 3. REGRESSION RESULTS FOR THE DIRECT EFFECTS ON WORK OUTCOMES

<table>
<thead>
<tr>
<th>Measure</th>
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</tr>
<tr>
<td>Education level</td>
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<tr>
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</tr>
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</tr>
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<tr>
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<tr>
<td>Years of service</td>
<td>.10 *</td>
</tr>
<tr>
<td>Psychological contract</td>
<td>.50 ***</td>
</tr>
</tbody>
</table>

F       | 48.67 *** | 18.66 *** | 69.10 *** | 58.90 *** |
R²      | .29 *** | .14 *** | .37 *** | .33 *** |
Adjusted R² | .28 *** | .13 *** | .36 *** | .33 *** |
Df      | 8,962  | 8,964  | 8,965  | 8,958  |

Work outcomes: 1=job satisfaction, 2=job security, 3=organizational loyalty, 4=organizational commitment
* p<.05 ** p<.01 *** p<.001

Hypothesis 5a predicted that psychological contract would be a positive mediator on the relationship between perceived organizational support and various work outcomes. As shown in Table 4, first, perceived organizational support was a significantly positive predictor of job satisfaction (β=.52, p<.001), job security (β=.30, p<.001), organizational loyalty (β=.56, p<.001), and organizational commitment (β=.56, p<.001). Second, perceived organizational support was a significantly positive predictor of psychological contract (β=.69, p<.001). Third, after perceived organizational support was controlled, psychological contract was a significantly positive predictor of job satisfaction (β=.25, p<.001), job security (β=.27, p<.001), organizational loyalty (β=.33, p<.001), and organizational commitment (β=.25, p<.001). Fourth, the effects of perceived organizational support on several work outcomes were all decreased (see Table 4), after psychological contract was controlled. Thus, Hypothesis 5a was supported.

Hypothesis 5b predicted that psychological contract would also be a positive mediator on the relationship between perceived supervisory support and several work outcomes. As shown in Table 5, first, perceived supervisory support was a significantly positive predictor of job satisfaction (β=.50, p<.001), job security (β=.26, p<.001), organizational loyalty (β=.49, p<.001), and organizational
TABLE 4. REGRESSION RESULTS FOR PERCEIVED ORGANIZATIONAL SUPPORT

<table>
<thead>
<tr>
<th>Measure</th>
<th>Predictor variables</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
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<td></td>
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<td>1 2 3 4</td>
<td>1 2 3 4</td>
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<tr>
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<tr>
<td>Years of service</td>
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<td>.14 ** .13 *</td>
<td>.10 * .02 .15 ***</td>
<td>.14 **</td>
</tr>
</tbody>
</table>

Perceived organizational support .52 *** .30 *** .56 *** .56 *** .69 *** .34 *** .11 ** .33 *** .38 ***
Psychological contract .25 *** .27 *** .33 *** .25 ***
F 55.36 *** 17.38 *** 75.47 *** 70.72 ***
R2 .35 *** .14 *** .42 *** .41 ***
Adjusted R2 .34 *** .14 *** .42 *** .40 ***
Df 9,933 9,935 9,936 9,930

Models 1 and 3: 1=job satisfaction, 2=job security, 3=organizational loyalty, 4=organizational commitment
Model 2: Psychological contract
* p<.05 ** p<.01 *** p<.001

TABLE 5. REGRESSION RESULTS FOR PERCEIVED SUPERVISING SUPPORT

<table>
<thead>
<tr>
<th>Measure</th>
<th>Predictor variables</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
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<tr>
<td>Control</td>
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<tr>
<td>Age</td>
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</tr>
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<td>Monthly salary range (HK$)</td>
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<td>Years of service</td>
<td>.10 * .02 .15 ***</td>
<td>.14 ** .13 *</td>
<td>.10 * .02 .15 ***</td>
<td>.14 **</td>
</tr>
</tbody>
</table>

Perceived organizational support .50 *** .26 *** .49 *** .50 *** .63 *** .31 *** .63 .23 *** .28 ***
Psychological contract .30 *** .31 *** .41 *** .33 ***
F 56.57 *** 16.42 *** 68.29 *** 62.00 ***
R2 .35 *** .14 *** .39 *** .37 ***
Adjusted R2 .34 *** .13 *** .39 *** .37 ***
Df 9,943 9,945 9,946 9,939

Models 1 and 3: 1=job satisfaction, 2=job security, 3=organizational loyalty, 4=organizational commitment
Model 2: Psychological contract
* p<.05 ** p<.01 *** p<.001

commitment (β=.50, p<.001). Second, perceived supervisory support was a significantly positive predictor of psychological contract (β=.63, p<.001). Third, after perceived organizational support was controlled, psychological contract was a significantly positive predictor of job satisfaction (β=.30, p<.001), job security (β=.31, p<.001), organizational loyalty (β=.41, p<.001), and organizational commitment (β=.33, p<.001). Fourth, the effects of perceived supervisory support on several work outcomes were all decreased (see Table 5), after psychological contract was controlled. Thus, Hypothesis 5b was also supported.

**DISCUSSION**

**Summary**

In the extant literature, several types of organizational change have been identified, such as restructuring, downsizing, pay or benefit cuts, reorganization of personnel or operations, reduction in work forces, cutback in operations, or computerization, [1] [33] [54] [72]. With the catalyst of globalization, local and international business environments have been increasingly competitive, organizational change has become an important, if not the
only, means to survive or succeed. Local universities, just like business firms, are also required to monitor and adapt to such continuous changes. For example, to catch up the technological trends, the Department of Chemistry and Biology at the University of California (UCLA) was reported as operating virtual office hours offering faculty and students 24-hour communication, electronic posting of courses and on-line question and answer services [1]. In Hong Kong, all the government-funded universities have been engulfed in tremendous organizational change due to the budget cut affected by the Asian financial crisis since 1997 and the reform of the education system in Hong Kong since 2000. In the current study, the participants demonstrate that their universities have encountered a considerable level of organizational change (with a mean of 3.54 out of a 5-point scale).

Although organizational researchers have addressed different aspects to explain the relationship between organizational change and work outcomes, applying the concept of social exchange to understand organizational change has appeared to be limited. Social exchange theory is usually used for understanding the exchange relationship in organizations [22]. Since organizational change involves changing the balance of exchanges and felt obligations in the organizations, the changes of employees’ work attitude and behavior thus becomes reasonable. Consistent with this line of reasoning, this research draws upon perceived organizational support theory and psychological contract theory and investigates the mediating role of perceived organizational support and psychological contract on the relationship between organizational change and several work outcomes.

Built upon social exchange theory, organizational support theory holds that employees’ perceived organizational support produces a felt obligation to care about the organization’s welfare and help the organization to achieve its goals [55] [64]. Consistent with the theory, this research suggests that the employees must get the impression that they are supported by their organizations and superiors in order to produce a felt obligation to care about the organization’s welfare and help the organization to achieve its goals when the organizational change is implemented. Otherwise, their work outcomes would be negatively influenced.

Besides perceived organizational support, the perception of support from supervisors is also proposed as an important factor mediates the negative effect of organizational change. According to leader-member exchange theory (LMX) [21], the developed relationship as a partnership between supervisors and employees that involves support, trust, information sharing, liking, respect, and reciprocal influence. If the partnership relationship between supervisors and employees is established, the obligated reciprocation of positive responses to favorable treatment is more likely to occur [5] [22].

Theoretical and Practical Implications

Some theoretical and practical implications from the major findings of the current study are worth noting. First, the results of the current study provide some evidence to support that organizational change negatively affects employees’ psychological contract. This is an important finding as it helps explain why employees are resistant to change and decreased in satisfaction and commitment at work. As changes in organizations are probably damage the established equity between employers and employees, which result in the violation of employees’ psychological contract to the organizations.

Second, the results reveal that perceived organizational support and perceived supervisory support mediate the negative impacts of organizational change on employees’ psychological contract. Furthermore, the effect of perceived organizational support is stronger than that of perceived supervisory support on psychological contract. Similarly, the mediating effect of perceived organizational support is also stronger than that of perceived supervisory support on the relationship between organizational change and psychological contract. After the mediating effect of perceived organizational support is controlled, the effect of organizational change on psychological change decreases. However, after the mediating effect of perceived supervisory support is controlled, the effect of organizational change on psychological change also decreases, indicating that the mediating effect of perceived supervisory support is much weaker than that of perceived organizational support. As such, to reduce the negative impact of organizational change, the support from their supervisors at the individual level, though it does have some positive effect, is unlikely to substitute the support from their employers at the organizational level. In order to implement the change successfully, the organizations should effectively manage employees’ perceptions of being supported by the organizations or employers.

Third, in view of the issues mentioned above, the potential problems from the administrative employees in the organizational change implemented in universities in Hong Kong should be concerned. The current study reveals that the administrative employees were facing considerable level of organizational change. However, their perception of organizational support was weaker than that of supervisory support. Although employees’ work attitude and behavior was not likely to be an immediate problem, the relatively low level of perceived organizational support of the employees may cause harms to organizational performance in the long run.

Limitations

Several limitations of the design of the current study and the findings should be considered. First, the single type of participants, i.e., only the administrative employees from a single industry, i.e., the government-funded universities in Hong Kong, might have limited the generalizability of the findings. Second, only the administrative employees whose personal information had posted on their official websites were collected as the sample source, which might cause sampling biases. Third, the data analyses were based on self-reports. It might create the problem of common method variance, which might be subject to informant biases [19]. Last, the survey was conducted by a cross-sectional method.
To confirm the findings in the current study, longitudinal studies in future are encouraged.

Conclusion

Organizational change has become a common practice nowadays. Organizations that are engaging in dramatic change increasingly alert the importance of employees who are able to cope with the change at the workplace [74] [75]. In particular, the organizations involving major strategic changes inevitably create tensions and conflicts [8] to the employees. To manage the employees' perceptions of organizational support an important means to minimize the negative impacts of organizational change on the employees' work attitude and behavior in order to allow the organizations to obtain the greatest advantages from the change.

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MOTIVATING THE LOWEST PAID WORKERS USING EQUITY THEORY AND THE FAST FOOD INDUSTRY AS A MODEL

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ABSTRACT
A common question in low pay industries is how do employers motivate the lowest paid workers? Even in high unemployment environments these jobs are readily available with employers knowing that at anytime their employees could switch to another low paying employer. In addition, employees know that wage increases are limited with also limited or non-existent promotion opportunities. These jobs also tend to be less pleasant and have inadequate or no benefits. Turnover is generally high. This paper explores how equity theory can be effectively used to motivate employees with limited pay incentives. An emphasis is placed on the fast food industry.

Keywords: equity theory, low pay positions, fast food industry

PAY AS A MOTIVATOR
Equity theory has a stronger empirical validity than many other organizational behavior theories and is viewed as a useful and powerful indicator of work outcomes [1] [2]. It has strong links to stress [2] burnout [3], turnover [4], and job satisfaction [5]. One aspect of equity theory asserts that de-motivation occurs if employees perceive their workplace inputs are greater than the outputs received for their work efforts [6] [7]. The employer goal is to get employees to continually evaluate their aggregate work inputs as less than their work outputs as this paper examines working at a fast food establishment.

One output is certainly the hourly wage. Fast food workers generally work at minimum wage or at a wage not much higher than minimum wage. Most employees are offered only part-time work and benefits are rare. Fast food workers already know they are low paid when taking employment in this industry. These positions are often viewed as first jobs and related work experience might be desired by the employer but is not necessary.

The positions are easy to obtain even in times of high unemployment. There is often not a celebration of winning if offered this type of job. Many fast food restaurants are always hiring and have signs posted communicating this message. Jobs are often designed (except for the cash register) so that even speaking English is not required. A common trend is to have a supervisor that speaks Spanish give food orders to non-English speaking employees. This allows an increased pool of applicants and potential hires that already have limited job opportunities because they do not speak English or speak it poorly. This also creates less pressure to raise wages if workers can be hired at the lowest legal hourly rate.

EQUIVALENT HOURLY RATE
Fast food should at least try to pay what other fast food establishments are paying [8]. This will reduce turnover and attract at least the same quality of worker if all else is equal. Paying a little more might actually cost less in the long run with lower turnover, more motivation, and even the attraction of a higher quality worker [9]. Customers can go elsewhere if receive poor service or poor food quality. This is a cost too. Workers do have friends that work other low skilled jobs and can easily compare pay and work conditions.

Perceptions of external pay inequity will increase job dissatisfaction and will not likely not attract or retain the better worker [7] [8]. All efforts should be made to match the hourly rate of competitors for employees. In addition, an argument can be made to pay a little more if this extra attracts and retains better workers. A small amount might not seem much from a financial standpoint for the worker but there is a principle to pay too as with most decisions. Workers have turned down jobs, quit jobs, or shown reduce morale even for just a five cent difference in hourly rate.

Creating external pay equity in the local fast food industry competing for workers is not difficult as far as comparisons of hourly rates. Completing informal salary surveys and listening to employee talk should provide adequate information for any adjustments for external equity for current fast food positions. Workers are not likely to turn down a job offer or quit a fast food position based on higher pay in another fast food establishment if the employer keeps up with local fast food pay comparisons.

Employers that pay below market risk getting job offer acceptances only from those potential employees that other fast food establishments have turned down. Employee satisfaction is also likely to suffer as a result.
Again, potential employees and employees are pay sensitive even when the amount seems insignificant to the employer [10].

Another aspect of work motivation in the Fast Food industry is the low pay itself even if it is competitive. Equity theory further deals with this issue in which effort must be comparable to the perceived reward to be viewed as equitable [7]. Few workers are going to endure a workplace with intense demands for low pay if other options are available. Fast Food employers must make sure that each shift is fully staffed and that equipment is user-friendly with the least discomfort for employees.

Heat lamps should be designed to keep food hot but not for the employees. Grills need to be designed with easy to clean materials. French fry machines should be designed for easy cleaning with self-cleaning as a goal. Better user-friendly equipment that still meets customer food excellence demands can be a competitive advantage for hiring and retention even if pay is equivalent elsewhere. Any methods to make food creation fun, less tiring, and rewarding should be highly considered even if this equipment is more expensive. Equipment makers should be notified of these desires particularly if the Fast Food establishment is a large chain that could potentially make large purchases.

**PAY COMPARISONS OUTSIDE OF FOOD INDUSTRY**

Unfortunately, Fast Food employers are not able to just be pay competitive with other fast food establishments and feel confident in their hourly rates. It is a much more complex pay issue as employees will also compare pay in other low skilled industries such as retail establishments and gas stations. Retail stores such as clothing, sports equipment, and varied general merchandise also desire quality workers and compete on pay and also work conditions. Dillard’s, Wal-Mart, Sears, Abercrombie & Fitch, Buckle, Old Navy, Gap, and Hobby Lobby would be good examples. These competitors are not only pay competitive, but can offer product discounts, a pleasant air-conditioned environment, and often a slower pace.

Some retail stores also offer a "cool" factor as far as working there. Friends can even sometimes easily visit, and if these employees want to go out later, they are not hot and sweaty, do not smell like food, or have hair that has been pressed down from a hat. In addition, employees getting a discount for retail clothing that would have been bought anyway is an enormous incentive for workers to not only seek out these employers but to also stay with them. Fast food chains could attempt to obtain discounts for their employees at establishments outside of the workplace in an attempt to restore some comparative equity concerning workplace benefits.

**CERTAIN FAST FOOD WORK POSITIONS**

Different work tasks may require different hourly rates. This will depend on whether tasks are rotated and how different the demands are for each task. Fast food is a type of work environment that equity sensitivity would be strong as tasks are generally routine and consistent from day to day making work effort observations somewhat simple and clear [11].

Those that work the cashier generally should look pleasant, have a friendliness to them, and be quick with the keyboard. Customers demand correct orders, employees that can enter orders quickly, and can get food prepared for them in a timely manner. The cashier position is often a higher stress job requiring excellent English, intelligence, and people skills.

There are certain personalities that thrive on this type of customer contact and would not be happy in the restaurant back area preparing the food. Food workers that deal with hot items and perhaps grease on a constant basis have a tough task role and sometimes feel lonely; however, some workers prefer less direct customer contact and would not like working a cash register. Workers that handle customers through the drive through tend to have the highest stress as customers are the most demanding.

Ideally, employees are matched to positions they like the most, but rotating can increase the perception of fairness and also allow a better understanding of the challenges of each position. In addition, rotation allows greater flexibility in scheduling and in situations in which a worker calls in sick, gets sick at work, quits on the job, or doesn’t show up. Management must be listening to their workers to hear perceptions of fairness and should react accordingly [12]. Fairness must also involve the scheduling of work hours.

**HIRING EMPLOYEE FRIENDS**

Employee pay is certainly an important issue in the fast food industry. However, fast food employers should encourage social aspects of these jobs to help workers form a work connection other than just hourly pay. Volunteer organizations pay nothing and are able to attract highly motivated and dedicated workers. Encouraging employee friends to apply can add to work enjoyment and give another reason to not switch employers. Tedious tasks can feel less tedious and there is now an immediate social support system [13] [14]. Quality employees also tend to have quality friends which is another advantage for employers. In addition, this is inexpensive recruiting.
Employers should consider giving a small bonus to employees that refer successful employees. The bonus would be given after at least 3 months on the job and the recruited employee must also be doing well. As part of getting to know employees, asking about their close friends and encouraging these friends to come in for an informal interview or just to take a restaurant tour should produce positive recruitment results. As possible, friends should be scheduled on the same shifts.

**EMPLOYEES SOCIALIZING ON THE JOB**

One criticism of hiring friends or the encouraging of making friends on the job is that employees might socialize too much instead of work. The key is to put boundaries and to show how it can be done without significant impact to work efficiency. There must be a win/win as far as socializing and it should be a part of multi-tasking that the younger generation has fully embraced. No one wants to work at a place that employees are treated like slave labor, and when there are plenty of job opportunities at this low pay level, the crack the whip employer is going to lose their quality employees.

Happy employees also work harder if guided properly and generate positive energy to customers. Management should find ways to encourage work conversations in a manner that doesn’t reduce work output. If possible, attempts should be made to recruit the more popular students as these students will help bring in more applicants and perhaps reduce turnover. Turnover of quality workers is extremely expensive and fast food work is often the least favored of all employers. Popular students make fast food a "cooler" option when considering employment opportunities.

**NEED FOR MONEY**

Workers do have different needs for the money obtained from working fast food [15]. A High School student that lives at home and has most meals provided by family is not needing income at the same level as a father or mother trying to support a family or someone that is completely on their own financially. Some High School students are looking for some extra spending money while others are also paying for their cell phone, a car, and/or car insurance.

Those that can’t survive on the low fast food hourly rate are going to quit without more hours and/or a higher hourly rate. Some might stay but will take second jobs which may lead to tiredness and less work productivity. The need for money will impact perceptions of pay equity along with turnover and work motivation. Employers must be sensitive to these needs as they get to know their employees.

If there is a potential career as an Assistant Manager with more pay, then this career should made known to everyone. If an employee must take a second job, then management should do its best to make a schedule to support this employee. For very high quality employees, extra hours that also involve overtime pay might help retain these employees without a second job and still be cost effective to the fast food establishment.

Management must make sure that employees are comfortable talking about their financial situations. Management that cares creates loyalty, good will, and more positive equity comparisons [8]. It also reduces employee theft from trying to increase equity outcomes. Employee theft has a link to feelings of inequity in the workplace [7].

**KEEPING IN TOUCH WITH CURRENT AND FORMER EMPLOYEES**

One advantage of hiring quality high school students to work in fast food is that employers might be able to persuade them to continue during college or college breaks. Facebook and email are free contact methods and a great way of keeping in touch with employees and former employees. Each fast food location should have their own Facebook account and attempts should be made to create a close family of workers and perhaps even with customers too.

The danger is that negative items or pictures might sometimes be posted so Facebook must be monitored regularly. Unfortunately, negative pictures or comments might also show up on other Facebook pages not controlled by the employer. We are in a time when every employee is carrying a cell phone and all cell phones have cameras and most have video too. These negative pictures and video are less likely to be taken and distributed if the workplace is perceived as equitable.

As far as recruiting pervious workers, a quick email from management to those home from college break to see if want to work some hours might lead to some needed new hires even if temporary. These hires might be particularly desirable in the summer when some employees would like to take some vacation time. Some employees attending college locally might even quit work during a rough academic semester, but wish to return during an easier academic semester. Some employees might have left to try another job because they could get the same pay but are unhappy and would return if asked. Keeping in contact with former employees is a valuable way of getting already trained employees to return. Quality employees should know they are welcome back and should be treated well when they quit. From an administrative standpoint,
there is little paperwork to rehire an employee versus hiring one for the first time.

**WORK GAMES AND PRIZES**

Another avenue to increase work enjoyment is to add work games and prizes. This is also another way to add to the social aspects of working in a fast food establishment. Games can also decrease the potential boredom or unpleasantness of some work tasks as perceived by some employees. Prizes do not have to have a high dollar value but should be of high value to employees. For students, an idea would be to award a free combo meal, but it must be given to one of their teachers. The prize of management washing employees' windshields or taking their uniforms home to wash would cost almost nothing but would be a bonding experience and mean a lot to many employees.

Other ideas might include hanging an employee's picture in a prize winner frame on the wall and adding a caption of what did to win or giving a special combo meal named after the employee for a week with some promotional discount to customers. Prize ideas are endless and the ideas that employees seem to value the most should be repeated. One way to increase a prize's financial value to an employee is to put the names of the last 25 prize winners into a hat and then draw out one name to give a bigger prize.

Prizes can help increase employee satisfaction and can be linked to customer satisfaction too. For example, prizes for incredible customer service. Other ideas might include getting employees to get ten friends, a club, or a team to come eat the fast food with all these customers getting large instead of small fries with combos or a T-Shirt to share. There could be employee awards for getting Mom or Dad's office to come in to eat with a food or other incentive such as a gift to a local charity, picture of office workers on wall, or something else creativity and visible that makes everyone feel good or excited.

Management should not recommend a prize such as a better work assignment (grilling hamburgers versus cleaning oil from fryer) as management should not highlight and give attention to the unpleasantness of certain jobs. Awards should not involve better work schedules as this could create inequity issues [7]. Prizes should be rewards and not punishments for others. Employees need to work together and not become rivals or threats.

**HELPING MEET ACADEMIC GOALS**

Another possible way to recruit and retain quality workers that are students is to create an academic incentive. This incentive also helps maintain work equity in the low-pay fast food industry. The Disney College Program has used this method by recruiting on college campuses for students to enter their paid internship program with a learning curriculum [16], although many of these students will cook burgers, fries, and serve drinks just like at a regular fast food restaurant. Yes, there are more interesting jobs at Disney but many are not and positions received are not typically known until the students reach Disney. Students get a place to stay and also attend classes and this experience is promoted as career building and fun.

College credit is possible at some learning institutions as this program is designed as internships with even a curriculum. Major fast food chains could easily copy some aspects of this program as a way of recruiting and retaining top workers. If setup properly, these internships could generate positive goodwill in the community and may create an employment equity preference over employer rivals.

Some chains already do offer the ability to apply for limited competitive college scholarships for their employees. Workers receiving scholarships should be given preference for length of employment and positive management recommendations. Meeting certain work goals could be part of the internship or scholarship application too so that work performance motivation is increased.

**WORKER EMPOWERMENT**

Even workers in low-pay and low-skill positions desire workplace participation. The day of "just do what you are told" is over as far as motivating and maintaining the morale of most employees. Because many organizations still do not recognize this fact, empowerment can be a competitive advantage with employees and in the fast food industry. There should be ample opportunity for workers to share their thoughts and ideas.

Brainstorming should even be encouraged on specific topics and rewarded in a positive valued manner. There could be an "idea" award. Real empowerment creates a perception of mutual respect and workplace ownership. This leads to higher workplace commitment and higher job satisfaction [17]. The fast food establishment also wins because there will be some new good ideas.

The theme should be continuous improvement and it must involve employees at all levels. There should never be a management response that something can't be improved, it has already been improved, or it is perfect. Sometimes, there is a need for multiple okay or poor ideas combined to get one incredible idea. This is how brainstorming should
function. Although great ideas do happen on their own, many happen through the exploration of many ideas.

Ideas should not be limited to restaurant processes, but to also advertising, marketing, hiring, promotion, and equipment. There should be no areas off-limits. Ideas could be shared in group speed meetings or even on a computer where others can share and add to proposed ideas.

**SELECTION OF CASHIERS AND FOOD PREPARERS**

Another tough aspects of recruiting is deciding where to place employees after they are hired. Ideally, potential employees will help management screen for position selections by letting their preferences be known. Employees placed in positions that are not wanted will create feelings of inequity. Complete honesty to applicants should be given based on restaurant needs. Some fast food establishments might rotate workers so that all workers become reasonably skilled to take on any duties as needed.

Employees not placed in their first choice should be given priority as preferred positions open. This helps restore equity and also seems fair. Student employees may have never worked a cash register, cooked fries, hamburgers, or other food products, or worked various fast food equipment such as ice cream, shake, or soda machines. Some positions even in a low skill workplace require more skill than other positions. Some equipment is dangerous if not operated or cleaned properly. Some equipment not maintained becomes a health hazard.

In addition, some employees will be found to not function well under high stress such as dealing with an angry customer or large crowds of customers such as after a football game or from a full bus of people that happens to stop for quick food. In addition, there is a difference between a lack of intelligence and a lack of experience when performing fast food positions. Slowness doesn't have to mean a lower IQ but can be a lack of ability that will grow after more hours on the job.

A lower intelligence, however, might work out fine with repetition and patience. Some positions might not even require the ability to speak full English, but this will mean that someone must be able to speak both languages to make this work arrangement function well. In addition, OSHA requires that any required safety training and materials must be in the other language.

Employee selection is important because employees that perform poorly impact customers and other employees. Because the hourly rate will be the same or almost the same as others, new employees that can't learn, show laziness or irresponsibility, or can't get along with others will impact the equity perceptions of the rest of the employees [7].

One positive aspect of the fast food work layout is that it is compact with a small team of scheduled employees, so social loafing would be more easily noticed and recognized making work inequity harder to hide [18]. In addition, even the most equity sensitive employees seem to be more satisfied if being paid the same hourly rate if working in a equally performing small group of employees [18].

Of course, management and peer pressure must act on any noticed inequity. Interview questions and perhaps testing that can eliminate these hiring choices even in times of high hiring need will be in the best interest of everyone. Those that have been given a chance to succeed and are not eventually performing on the job, should be terminated. Workers do observe the work efforts of other workers and expect common efforts [19]. Performance should include getting along with and respecting other employees and not just task performance.

Work itself has its own struggles without any extra stress of jerk employees. Reference checking and referrals from other employees should help increase hiring success. If the potential hire is a student, asking for the name of a teacher might help in making an appropriate hiring decision. There is a pride felt by other employees when it is known that not everyone is considered good enough to work at the fast food restaurant.

**MANAGEMENT AT FAST FOOD RESTAURANTS**

Most chain Fast Food restaurants use the supervisor model of having one manager and multiple assistant managers. The management team is critical for maintaining perceptions of equity in the workplace. This connection is even stronger in low hourly rate positions in which pay incentives are weak motivationally and current employees have constant opportunities to work elsewhere at other low-paid positions. There is a need for managers to form relationships with employees in which guilt instead of relief would be felt if employees consider changing jobs.

Employees do become more connected with the management than the fast food restaurant itself although both connections are important. Poor management will hurt employee perceptions of equity. Management can make the difference between quality workers choosing to work fast food versus what many would argue are better more pleasant employment opportunities elsewhere. Fast food establishments must provide help with solid guidance.
in not only choosing the regular workers but also in choosing management.

Training of management is essential and must be reinforced with periodic videos, quizzes, and check sheets to reinforce what was learned and practiced so it is not quickly forgotten. Most leadership training could be given on-line so it is consistent, inexpensive, and periodic. Chosen managers must be not only competent in food operations but must be compassionate caring individuals that know that employee motivation must come mostly from outside of the hourly paycheck in this low paid industry. Management must be sensitive to employee recognition [20], respect, social support, and must understand how to make the workplace a positive experience and perhaps even fun.

CONCLUSIONS

While employees do react differently to inequity and some are more sensitivity to it than others [21], inequity overall creates a powerful negative motivational impact in the workplace [22] [6] [7]. This is particularly true in the fast food industry because of the low pay, low promotion potential, and low desirability of these types of positions. A fast food restaurant should pay an hourly rate that is at least what other fast food restaurants are paying their workers.

There should be attempts to offer outside of work discounts to compete with retail employers that gives employee discounts. Efforts should be made to create an user-friendly equipment work environment so that equipment is easy to clean and use with little environmental hardship such as high heat on employees. Care should be given in the creation of a pleasant work environment. Management must hire carefully and should encourage employees to refer friends for positions. The workplace should have acceptable socializing to reduce boredom and fatigue.

A more equitable work environment can also be enhanced by management keeping in touch with current and former employees on a personal basis, adding work games and prizes, and helping employees meet academic goals as applicable. In addition, equity can be strengthened by empowering workers and placing workers properly in positions. Finally, most of the recommendations made to maintain equity will fail without the hiring and training of managers that are competent in food operations and in being compassionate and caring with employees.

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The Supporting Actor in Enterprise Executives’ Decision-making: A Competitive Intelligence Perspective

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ABSTRACT

The purpose of this study is to investigate empirically how competitive intelligence (CI) impact executives’ decision-making support and how decision-making subsequently influence strategic benefits expansion in organization. A questionnaire survey was conducted from 126 enterprise executives in Taiwan. Results indicate that competitive intelligence comprises three separate constructs: the process of CI, the product of CI and prior knowledge. This study is the first effort to examine empirically on a key aspect of CI. It provides a concept to both academicians and practitioners on how to conduct a comprehensive quantitative strand in terms of competitors, competitive environment, situation and strategy through proactive CI activities.

Keywords: competitive intelligence, decision-making support, organizational strategic benefits

Introduction

Competitive intelligence (hereafter CI) is the component of business intelligence aimed at gaining strategic advantage, as proposed by Porter [40] [42]. Per se, CI includes competitor intelligence as well as intelligence collected on customers, suppliers, technologies, environments, or potential business relationships [20] [26] [42]. CI is regarded as a system of environmental scanning which integrates the knowledge of everyone in the company [1]. The concept of CI has a rich heritage [1] [33] and can be traced back over 5,000 years of Chinese history [1] [48]. Porter’s [36] seminal work on strategic management and competitive analysis, which focused on tracking specific competitor behavior and linking competitor analysis to competitive strategy, touched off an avalanche of publications on CI [39] [42]. CI is not just market research or business scanning but both a process and a product (intelligence) [1] [22] [24] [32] [45]. Moreover, CI is also a process of knowing what the competition is up to and staying on step ahead of them, by gathering information about competitors and, ideally, applying it to short and long-term strategic planning [19] [50]. Kahaner [32] argued that CI is conceptualized as a process of monitoring the competitive environment, with a goal to provide actionable intelligence that will provide a competitive edge to the organization.

Prior studies have paid a great attention to understanding such as an empirical study on the construct exploration, validation and equivalence [42]; a multiphase precedent to marketing strategy [15]; assessing the impact of using the internet [50]; CI process and tools for analysis [8] and so on [10] [36], which probably encourage current and potential academicians and practitioners to take an innovative research vision on those broad CI subjects. Although their findings are meaningful, the actual supporting actor of CI in executives’ decision-making is still inconclusive. The need for organizations to be aware of developments in their business environment ought to be a concept that is well understood, appreciated, and well represented in the literature [1]. Porter [40] asserted that whilst companies were carrying this activity out informally, in his opinion this was nowhere near sufficient. He also advocated the need for a structured intelligence process at all times in order to continuously and systematically identify business opportunities and threats.

In order to consolidate aforementioned relationship, this study provides a concept to both academicians and practitioners on how to conduct a comprehensive quantitative strand in terms of competitors, competitive environment, competitive situation and competitive strategy through proactive CI activities. It is also necessary to understand how factors related to CI and situational factors (e.g., environmental conditions and competitor situation) that influence the causal relationship between decision-making support and organizational strategy benefits. A review of previous studies affords no model to represent how to using the CI as a supporting actor for executives’ decision-making. The purpose of this research is to develop a conceptual framework that incorporates aspects of theory of behavioral decision-making to provide a deeper understanding of the relationship between executives’ decision-making support and organizational strategic benefits. We outline our research purposes as follows:

1. To investigate the concept of competitive intelligence (CI) and the support of CI on the decision-making stage.
2. To examine the influences of CI on decision-making support and organizational strategic benefits.

Literature Review

Competitive Intelligence

The formal exploration process of the marketing strategy paradigm has been linked with the environmental scanning literature as a basis for gathering and processing the information and the information processing theory paradigm [11] [15]. In fact, the importance of environmental scanning has often been linked to firm performance [13] [15] [25]. Belich and Dubinsky [3] summarized the integration of environmental scanning and information processing for effective strategic decision making as “The ability to develop adequate organizational mechanisms for information acquisition, dissemination, and effective utilization may be precursors to identifying and effectively adapting to major market shifts.”.

CI refers to actionable information about external business
environment that could affect a company’s competitive position [22]. CI is not a euphemism of industrial espionage or economic espionage [38] [41]. A key maxim of CI is that 90% of all information that a company needs to make critical decisions and to understand its market and competitors is already public or can be systematically developed from public data [34] [50]. Blankenship et al. [4] posited that CI involves three major functions: the collection and storage of data, the analysis and interpretation of data, and the dissemination of intelligence. Saayman et al. [38] verified the process of CI and comprised six key stages which in terms of planning and focus; collection; analysis; communication; process; organizational awareness which suggested by Calof and Dishman [7], to measure the direct impact on all of the various phases in a model of CI process and structure, the process can have a discrete beginning and end or it can be ongoing and iterative, designed to gather and disseminate information throughout an individual organization, or ultimately, throughout an entire business ecosystem [50].

Decision-making support
Simon [45] [46] proposed a three-phase process of decision making: the intelligence phase, the design phase and the choice phase. Executives are especially dependent on doing the first of these, the intelligence phase as called the CI phase well. The current competitive environment may be even more volatile and unpredictable due to increased globalization, mergers and acquisitions, and an explosion in technology applications and new business practices [51]. In particular, executives need the following supporting functions for their decision-making: (1) an early warning of threats and opportunities; (2) support for the strategy development process; (3) assistance within instilling a sense of urgency and motivation toward action; (4) support for strategic and operational decision making [43]. Moreover, enterprise executives’ cognitive limits require some prioritization of information [45]. Enterprise executives need accurate, timely information in order to make effective decision. Attention is often focused on key subsets of the available data, while some potentially external important data sources are ignored [28].

Additionally, strategic decisions in many firms are often influenced by design characteristics of the firm’s scanning systems [52]. Daft et al. [13] claimed that as uncertainty increased, information processing activities raised. Environmental uncertainty therefore leads to increasing information processing activities within firms [11] [13]. Regardless of the complexity and uncertainty inherent in any environment, information processing (a firm’s ability to adapt to existing market conditions) is largely dependent on its ability to process relevant market information effectively [18]. Thus, the decision-making support is crucial to certain strategic decisions which may instrumental to the growth of strategic effectiveness in organization.

Organizational Strategic Benefits
Technologies such as decision support systems are helpful in solving many kinds of problems, especially those that are based on quantitative data and/or are tactical in scope [43] [51]. Sauter and Free [43] asserted that decision makers can benefit greatly from a tool that tracks and organizes qualitative and other nebulous information. Such a tool would help cultivate and leverage an organization’s intellectual assets to help users address decision making in a more informed fashion. Glueck and Jauch [45] examined several studies (e.g. [25] [37]) and determined that in all of the studies that they reviewed, a positive correlation between environmental assessment and performance was demonstrated. A considerable amount of research has emerged on the subject of CI and its relationship to the strategic planning process. The literature based on CI often stresses its importance on organizational performance [15] [50]. CI supports a company a competitive advantage and better organization performance by permitting better business planning; new product introduction success and new market development [1] [13] [14] [26] [40]. Brockhoff [5] contends that better information, including competitor technological intelligence information is needed to better support strategic decision [13] [14] [50].

It is commonly agreed that CI directly impacts the bottom line of a company, researches tried to measure the CI’s value to organizations although a proof for this assumed impact could not be easy identified [6] [9] [30] [42]. The major questions that researchers in the field of CI have tried to answer but still face whether companies are able to quantify the benefits. The empirical part of this study does not solely focus on issues like the development of CI in Taiwan or the organizational circumstances of CI practices in Taiwan companies, the review of the existing CI literatures yielded the blurred in the existing literature that this study wants to close. As a matter of fact, Both CI academicians and practitioners around the world have to deal with the challenge of justifying their work without being able to measure the outcomes of their activities. In the current academic literature a few attempts were made to fill this gap but they were not very successful [9] [10] [15] [42].

Research Framework and Hypotheses
Doll and Torkzadeh (1991) described a system-to-value chain of system success constructs [16]. The constructs vary from beliefs, to attitudes, to behavior (system-use), to the social and economic impacts of IT. The system-to-value chain suggested an alternative role for the usage construct in a downstream research agenda – as an independent variable [16] [50]. Doll and Torkzadeh [17] adapted the multidimensional measure of system-use which is identified by Hirschhorn and Faruhi [31] to measure downstream impact of system work. They asserted that a multidimensional system-use measure enables investigation into the patterns and extent of system usage along organizationally relevant dimensions [17] [50]. In a similar vein, this study examines the downstream effects of CI on decision-making support and its subsequent effects on organizational performance (Fig. 1).
This research attempts to propose a model of decision-making support with a CI perspective [2] [9] [15] [30] [42]. Therefore, we modify the model as Fig. 2.

The process and product within CI activities and their impacts on decision-making support are measured using the variables adapted from various studies and research on the functions of CI [9] [10] [30] [32] [42]. CI is measured in terms of process [9] [15] [42], product [19] [22] [24] [26] and executives’ prior knowledge [35] [44]. Since the decision-making support is a critical aspect, it would be essential to measure the rapidity of decision-making support and the accuracy of decision-making support [43] [51]. The subsequent organizational influence of decision-making support is measured according to three strategic benefits: (1) revenue prospect; (2) cost evaluation and (3) managerial effectiveness [47] [50].

Hypotheses

Strategy is a framework within which decisions are made, reflecting the future of an organization and the direction which it should take. Feurer and Chaharbaghi [21] discussed how the formulation of competitive strategies are developed using a structured process which requires a knowledge base of external environment together with an understanding of the potential impact of different strategies. They also identified another important factor in the formulation of strategy, is to reflect the dynamics of change in the market or industry [21]. The development of strategies can, and should, rest heavily on the current market situation without considering all potential which could cause the failure of a strategy. Although there is an extensive body of literature on strategic planning and strategy formulation, there is still a lack of a suitable framework, which can provide the basis for integrating CI into the decision-making support process. Badr et al. [2] examined four stages of the strategic decision making process and its relationship with CI. According to well-established theories and previous empirical studies in CI [2] [9] [22] [30], the process of CI constructs consists of four dimensions: (1) setting strategy objectives; (2) strategic analysis; (3) strategy formulation; and (4) implementation/control [2] [9] [15]. Therefore, the first hypothesis of this study is:

**H1. The process of CI will have direct influence on decision-making support.**

In Teo and Choo [49] study, the product of CI construct consists of two dimensions: primary and secondary product. Primary product of CI is defined as the gathering of intelligence specifically for the project at hand. Secondary product is defined as the research for available intelligence, already gathered for some other purpose [46]. As the literature review on the product of CI, the primary product is a priority which needed to acquire for executives’ decision-making support (e.g. patent information and new product/service/customer feedback information). The secondary product is a necessary to get which may benefit a firm in a long term business strategy formulation. Teo and Choo [50] collected the major related CI products that a firm may study and evaluation for executives’ decision-making support. Thus, the following hypothesis is put forth.

**H2. The product of CI will have direct influence on decision-making support.**

No longer can management use intuition alone to drive their decision making. Rather, management needs systematic support regarding information external to the organization as the basis of decision making even when such data are qualitative in nature [43]. Executives’ prior knowledge is also critical importance [44]. Conceptually, executives’ prior knowledge is expected to moderate the effect of decision-making support on organizational strategic benefits. It is often important for CI to be contributed to the executives in their decision-making support and even more importantly, to the top management so that strategic decision making can be improved. Hence, it follows the following hypothesis.

**H3. Executives’ prior knowledge will have direct influence on decision-making support.**

The strategic benefits of improved decision-making support are indicated by revenue prospect, cost evaluation and managerial effectiveness. These strategic benefits improve the overall performance of an organization [47]. CI supports a firm a competitive advantage through revenue prospect [22] [32]. Subramanian and Isfak [48] claimed that firms having advanced systems to monitor their competitors’ activities exhibited greater profitability. By using CI, decision-making support makes it possible to take advantage of the cost evaluation of streamlining the supply chain to maximize competitive profit. The application of CI can also lead to cost evaluation in business process. Managerial effectiveness is also enhanced through the use of CI, which is positively related to firm performance. Improved decision-making support through CI activities allows better business planning, speed of decision-making and improved decision-making accuracy. Customer relationships can be built or strengthened.
though the improved convenience of on-demand access to essential information. Consequently, it is expected that better CI information would enhance organizational flexibility, responsiveness to customer needs and production operations, decision making speed and accuracy, and improving forecasting accuracy [50]. Therefore, the following hypothesis is proposed.

H4. Decision-making support through CI activities will have direct influence on organizational strategic benefits.

**Method**

**Operationalization of variables**

Table 1 summarizes the operational definitions of research constructs and their citation. Minor revisions of these constructs were performed in order to meet our study context.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Definition</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Process of CI</td>
<td>To collect, store, analyze, and provide access to data to help companies make better business decisions</td>
<td>[2][9][10][11][42]</td>
</tr>
<tr>
<td>Setting Strategic Objective</td>
<td>Strategic objectives are what the company want to achieve</td>
<td>[2][9][10][42]</td>
</tr>
<tr>
<td>Strategic Analysis</td>
<td>Strategic analyst would consider related information</td>
<td>[2][9][10]</td>
</tr>
<tr>
<td>Strategy Formulation</td>
<td>Concerns the future position of products and markets</td>
<td>[2][9][10]</td>
</tr>
<tr>
<td>Implementation and Control</td>
<td>A planned and thorough implementation plan is vital to the ultimate success of any strategy</td>
<td>[2][9][10]</td>
</tr>
<tr>
<td>The Product of CI</td>
<td>An actionable information about the external business environment that could affect a company’s competitive position</td>
<td>[19][22][24][30][32][34]</td>
</tr>
<tr>
<td>Primary Research</td>
<td>The gathering of new intelligence specifically for the project at hand</td>
<td>[22][24][26][42][50]</td>
</tr>
<tr>
<td>Secondary Research</td>
<td>The available intelligence, already gathered for some other purpose</td>
<td>[22][24][26][42][50]</td>
</tr>
<tr>
<td>Prior Knowledge</td>
<td>The supporting intelligence for executives’ decision-making</td>
<td>[44][45][46]</td>
</tr>
<tr>
<td>Industrial Knowledge</td>
<td>Executives’ accumulated experience</td>
<td>[44][45][46]</td>
</tr>
</tbody>
</table>

**Table 1. Definition of study construct**

**Sample and procedures**

In this study, we would like to investigate the impact of decision-making support through CI activities. Therefore, the executives chosen were drawn from NCCU Global EMBA program. The companies included multinational companies and local companies. A questionnaire survey was used to collect data for this study. The questionnaire was first pre-tested with one professor and five doctoral students. Modifications were made and the revised questionnaire was pilot-tested with three senior executives in local companies. Since there were no major comments, the questionnaire was deemed ready for data collection. The questionnaires were sent to 200 executives via e-mail. A follow-up e-mail was made 2 weeks later to non-responding firms.

Table 2 is a list of demographic analysis. In this survey, the
number of total respondents is 200 (100%), the number of actual collected sample is 128 (64%) and the number of valid questionnaire sample is 126 (63%), respectively.

Table 2. Respondents’ demographics (N***=126)

<table>
<thead>
<tr>
<th>Category</th>
<th>Basic information of respondents</th>
<th>N***</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male</td>
<td>98</td>
<td>77.8%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>28</td>
<td>22.2%</td>
</tr>
<tr>
<td>Job title</td>
<td>Chairman, CEO, COO, President, GM, Vice President</td>
<td>39</td>
<td>31.0%</td>
</tr>
<tr>
<td></td>
<td>Associate Vice President, Senior Manager, Manager</td>
<td>21</td>
<td>16.7%</td>
</tr>
<tr>
<td></td>
<td>Assistant Manager, Supervisor, Others</td>
<td>66</td>
<td>52.4%</td>
</tr>
<tr>
<td>Work seniority</td>
<td>Below 5 years</td>
<td>23</td>
<td>18.3%</td>
</tr>
<tr>
<td></td>
<td>6 ~ 10 years</td>
<td>30</td>
<td>23.8%</td>
</tr>
<tr>
<td></td>
<td>11 ~ 15 years</td>
<td>20</td>
<td>15.9%</td>
</tr>
<tr>
<td></td>
<td>16 ~ 20 years</td>
<td>23</td>
<td>18.3%</td>
</tr>
<tr>
<td></td>
<td>Above 20 years</td>
<td>30</td>
<td>23.8%</td>
</tr>
<tr>
<td>Education</td>
<td>Under university</td>
<td>1</td>
<td>0.8%</td>
</tr>
<tr>
<td></td>
<td>University</td>
<td>73</td>
<td>57.9%</td>
</tr>
<tr>
<td></td>
<td>Master above</td>
<td>52</td>
<td>41.3%</td>
</tr>
<tr>
<td>Enterprise scope</td>
<td>Under 50</td>
<td>25</td>
<td>19.8%</td>
</tr>
<tr>
<td></td>
<td>51 ~ 100</td>
<td>7</td>
<td>5.6%</td>
</tr>
<tr>
<td></td>
<td>101 ~ 500</td>
<td>19</td>
<td>15.1%</td>
</tr>
<tr>
<td></td>
<td>501 ~ 1,000</td>
<td>14</td>
<td>11.1%</td>
</tr>
<tr>
<td></td>
<td>1,000 Above</td>
<td>61</td>
<td>48.4%</td>
</tr>
<tr>
<td>Industry sector</td>
<td>Information technology</td>
<td>58</td>
<td>46.0%</td>
</tr>
<tr>
<td></td>
<td>Finance</td>
<td>14</td>
<td>11.1%</td>
</tr>
<tr>
<td></td>
<td>Electrical and Electronics</td>
<td>19</td>
<td>15.1%</td>
</tr>
</tbody>
</table>

Table 3. Summary of construct loadings and reliability

<table>
<thead>
<tr>
<th>Factors</th>
<th>Items</th>
<th>Loading</th>
<th>Mean</th>
<th>S.D.</th>
<th>AVE</th>
<th>Composite reliability</th>
<th>Cronbach's Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSO</td>
<td>SSO2</td>
<td>0.723</td>
<td>4.065</td>
<td>0.818</td>
<td>0.552</td>
<td>0.832</td>
<td>0.730</td>
</tr>
<tr>
<td></td>
<td>SSO4</td>
<td>0.734</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SSO5</td>
<td>0.765</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SSO6</td>
<td>0.750</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SA2</td>
<td>0.636</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SA4</td>
<td>0.689</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SA5</td>
<td>0.811</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>SA6</td>
<td>0.714</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SF2</td>
<td>0.712</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SF3</td>
<td>0.742</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SF4</td>
<td>0.780</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IC1</td>
<td>0.755</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IC2</td>
<td>0.719</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>IC3</td>
<td>0.721</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IC5</td>
<td>0.679</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PR4</td>
<td>0.797</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PR5</td>
<td>0.828</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>PR6</td>
<td>0.866</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SR2</td>
<td>0.817</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SR6</td>
<td>0.866</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SR7</td>
<td>0.845</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IK1</td>
<td>0.804</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IK2</td>
<td>0.885</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IK3</td>
<td>0.912</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Descriptive statistics

Hair et al. [28] recommended an acceptance level of 0.7 for the composite reliability. As summarized in Table 3, the composite reliability values of all constructs range from 0.789 to 0.914 in our model were greater than 0.70 suggested by Bagozzi and Yi [6] and meet this criterion. For convergent validity, two criteria should be met as suggested by Fornell and Larcker [22]. First, all of the factor loadings should not only be significant but also exceed 0.5. Second, average variance extracted (AVE) of each construct should exceed the variance due to measurement error for that construct (i.e., AVE should be greater than 0.5). The values for average variance extracted from each construct (ranging from 0.512 to 0.774) also exceeded the threshold level (0.5) and all item loadings ranging from 0.636 to 0.912 are significant at the five-percent significance level, indicating convergent validity.

<table>
<thead>
<tr>
<th>Industry sector</th>
<th>Manufacture</th>
<th>Trade</th>
<th>Others</th>
<th>Below 5 years</th>
<th>6 ~ 10 years</th>
<th>11 ~ 15 years</th>
<th>16 ~ 20 years</th>
<th>20 years Above</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9</td>
<td>10</td>
<td>16</td>
<td>16</td>
<td>10</td>
<td>15</td>
<td>11</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td>7.1%</td>
<td>7.9%</td>
<td>12.7%</td>
<td>12.7%</td>
<td>7.9%</td>
<td>11.9%</td>
<td>8.7%</td>
<td>58.7%</td>
</tr>
</tbody>
</table>

N*: Number of survey = 200
N**: Number of collected = 128 (64%)
N***: Number of valid questionnaire = 126 (63%)
Discriminant validity evaluated the extent to which a construct and its indicator variables differed from another construct and its indicator variables [7]. The square root of the AVE should be greater than the correlations between the construct and its indicator variables. Table 4 presents the correlations among constructs, with the square root of the AVE on the diagonal. The correlation between each pair of constructs was less than the corresponding square root of average variances extracted (diagonal values), providing evidence of discriminant validity.

### Table 4. Descriptive statistics and correlations among study variables

<table>
<thead>
<tr>
<th>SSO</th>
<th>SA</th>
<th>SF</th>
<th>IC</th>
<th>PR</th>
<th>SR</th>
<th>IK</th>
<th>SI</th>
<th>RDS</th>
<th>ADS</th>
<th>RP</th>
<th>CE</th>
<th>ME</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSO</td>
<td>0.743</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SA</td>
<td>0.684</td>
<td>0.715</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF</td>
<td>0.522</td>
<td>0.637</td>
<td>0.745</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IC</td>
<td>0.577</td>
<td>0.687</td>
<td>0.536</td>
<td>0.919</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PR</td>
<td>0.426</td>
<td>0.374</td>
<td>0.391</td>
<td>0.496</td>
<td>0.831</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SR</td>
<td>0.459</td>
<td>0.428</td>
<td>0.342</td>
<td>0.410</td>
<td>0.442</td>
<td>0.843</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IK</td>
<td>0.248</td>
<td>0.312</td>
<td>0.206</td>
<td>0.282</td>
<td>0.195</td>
<td>0.268</td>
<td>0.868</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SI</td>
<td>0.424</td>
<td>0.326</td>
<td>0.283</td>
<td>0.360</td>
<td>0.381</td>
<td>0.294</td>
<td>0.375</td>
<td>0.880</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RDS</td>
<td>0.507</td>
<td>0.520</td>
<td>0.383</td>
<td>0.501</td>
<td>0.428</td>
<td>0.430</td>
<td>0.316</td>
<td>0.306</td>
<td>0.835</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADS</td>
<td>0.488</td>
<td>0.466</td>
<td>0.469</td>
<td>0.493</td>
<td>0.504</td>
<td>0.382</td>
<td>0.220</td>
<td>0.417</td>
<td>0.649</td>
<td>0.825</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RP</td>
<td>0.453</td>
<td>0.527</td>
<td>0.398</td>
<td>0.572</td>
<td>0.362</td>
<td>0.446</td>
<td>0.198</td>
<td>0.291</td>
<td>0.462</td>
<td>0.521</td>
<td>0.817</td>
<td></td>
</tr>
<tr>
<td>CE</td>
<td>0.468</td>
<td>0.543</td>
<td>0.346</td>
<td>0.578</td>
<td>0.412</td>
<td>0.456</td>
<td>0.263</td>
<td>0.280</td>
<td>0.564</td>
<td>0.446</td>
<td>0.755</td>
<td>0.799</td>
</tr>
<tr>
<td>ME</td>
<td>0.469</td>
<td>0.484</td>
<td>0.419</td>
<td>0.493</td>
<td>0.429</td>
<td>0.541</td>
<td>0.273</td>
<td>0.313</td>
<td>0.601</td>
<td>0.571</td>
<td>0.576</td>
<td>0.638</td>
</tr>
</tbody>
</table>

Structural modeling analysis

Fig.3 shows the summary of the structural model resulting from the PLS analysis. This table sets out the explained variance by model (R²), the standardized path coefficients (β), and t-values observed with the level of significance achieved from the bootstrap approach. The results showed that the process of CI had a significant effect on decision support (β=0.438, p<0.001) and also the product of CI and V (β=0.256, p<0.001), supporting hypotheses H1 and H2 (as suggested).
illustrated in Fig.3). The results also showed that decision support had a significant, direct influence on strategic benefit ($\beta=0.655$, $p<0.001$), hypothesis H4 supported. Moreover, prior knowledge had an influence ($\beta=0.123$, $p<0.01$) on decision support, hence, H3 was also supported.

Fig.3 Results of structural modeling analysis
Conclusions

While this paper illustrated the use of CI as a supporting actor in enterprise executives’ decision-making, it would be of use to any organization pursuing strategic or competitive decision-making support. Further, the model provides enterprise executives accessing to the information earlier than other forms of data gathering since the model encourages executives to enter information early, and certainly before rules of statistical significance would apply. This, in turn, allows the enterprise executives to act upon the information before competitors have access to it or before it could be damaging in the eyes of customers, employees, or constituents.

REFERENCES (BIBLIOGRAPHY)


DEANFIS – A FUZZY MULTI-DIMENSIONAL APPROACH TO DECISION-MAKING USING DATA ENVELOPMENT ANALYSIS AND NEURO-FUZZY SYSTEMS

Rashmi Malhotra, St. Joseph’s University, (610) 660-3497, rmalhotr@sju.edu

ABSTRACT
To screen consumer loan applications, loan officers use many different methods besides intuitive judgment and experience. They use mathematical techniques such as credit-scoring models and traditional statistical models. In addition, many financial institutions use artificial intelligence methods such as expert systems, artificial neural systems, and fuzzy logic. This study proposes the development of a decision support system that uses a combination of data envelopment analysis and neuro-fuzzy systems. Thus, the decision support system derives benefit from both methodologies to provide a comprehensive review of a loan applicant.

Keywords: Benchmarking, Data Envelopment Analysis, Neuro-fuzzy systems, Decision Support Systems.

INTRODUCTION
A business organization’s objective is to make better decisions at all levels of the firm to improve performance. Typically organizations are multi-faceted and complex systems that use uncertain information. Therefore, making quality decisions to improve organizational performance is a daunting task. Organizations use decision support systems that apply different business intelligence techniques such as statistical models, scoring models, neural networks, expert systems, neuro-fuzzy systems, case-based systems, or simply rules that have been developed through experience. Managers need a decision-making approach that is robust, competent, effective, efficient, and integrative to handle the multi-dimensional organizational entities. The decision maker deals with multiple players in an organization such as products, customers, competitors, location, geographic structure, scope, internal organization, and cultural dimension (Porter, 1980). Sound decisions include two important concepts: efficiency (return on invested resources) and effectiveness (reaching predetermined goals). However, quite frequently, the decision maker cannot simultaneously handle data from different sources. Hence, I recommend that managers analyze different aspects of the data from multiple sources separately and integrate the results of the analysis. This study proposes the design of a multi-attribute-decision-support-system that combines the analytical power of two different tools: data envelopment analysis (DEA) and fuzzy logic. DEA evaluates and measures the relative efficiency of decision making units that use multiple inputs and outputs to provide non-objective measures without making any specific assumptions about data. On the other hand fuzzy logic’s main strength lies in handling imprecise data. This study proposes a modeling technique that jointly uses the two techniques to benefit from the two methodologies. A major advantage of the DEA approach is that it clearly identifies the important factors contributing to the success of a decision. In addition, I also propose the use of a neuro-fuzzy model to create a rule-based system that can aid the decision-maker in making decisions regarding the implications of a decision. One of the important characteristics of neuro-fuzzy systems is their ability to deal with imprecise and uncertain information. The neuro-fuzzy model integrates the performance values of a set of production units derived by ranking using DEA to create IF-THEN rules to handle fluctuating and uncertain scenarios. Thus, a decision maker can easily analyze and understand any decision made by the neuro-fuzzy model in the form of the easily interpretable IF-THEN rules. Finally, this study will extend my earlier work on the application of neural network models and neuro-fuzzy models to decision-making. In these studies, I compared the performance of neural network systems and neuro-fuzzy systems with statistical models. In both cases, neural systems and neuro-fuzzy systems outperformed the statistical models. I propose to further improve the neuro-fuzzy models by combining them with DEA models.

LITERATURE REVIEW

Neural Networks and Neuro-Fuzzy Literature
Many studies highlight the use of artificial neural systems in business applications. Anders, Korn, and Schmitt (1998) use statistical inference techniques to build neural network models to explain the prices of call options on the German stock index DAX. They show that statistical specification strategies lead to parsimonious networks that have a superior out-of-sample performance when compared to the Black-Scholes model. Ntungo and Boyd (1998) report that out-of-sample neural network trading returns for corn, silver, and Deutsche mark futures contracts are positive and at about the levels as the returns with ARIMA models. Desai and Bharati (1998) test the efficacy of neural networks in predicting returns on stock and bond indices. They find that the neural network forecasts are conditionally efficient with respect to linear regression models for large stocks and corporate bonds, whereas the evidence is not statistically significant for small stocks and intermediate-term government bonds. Zhang and Hu (1998) illustrate the use of neural networks in forecasting UK pound/U.S. dollar exchange rate. They report that neural networks outperform linear models, particularly when the forecast horizon is short. Zhang, Hu, Patuwo, and Indro (1999) show that neural networks are significantly outperform logistics regression models in bankruptcy prediction. Indro, Jiang, Patuwo, and Zhang (1999) show that neural networks outperform linear models in forecasting the performance of mutual funds that follow value, blend, and growth investment styles. Thus, all the above-mentioned studies provide mixed evidence regarding the potential of neural networks to analyze, evaluate, and predict many financial systems. Wong, Wang, Goh, and Quek (1992)

Data Envelopment Analysis Literature

Recently, many studies have illustrated the use of DEA, a non-parametric methodology to analyze different aspects of business entities. The details of the DEA model are discussed in the next section. In contrast to other methodologies, DEA is one of the methods that have traditionally been used to assess the comparative efficiency of homogenous operating units such as schools, hospitals, utility companies, sales outlets, prisons, and military operations. More recently, it has been applied to banks (Haslem, Scheraga, & Bedingfield, 1999), railroad efficiency, airport efficiency, retailing, and mutual funds (Haslem & Scheraga, 2003; Galagedera & Silvapulle, 2002; McMullen & Strong, 1998; Murthi, Choi, & Desai, 1997). Zhu (2000) uses data envelopment analysis to develop a multi-factor financial performance model that recognizes tradeoffs among various financial measures. Kao and Liu (2004) compute efficiency scores based on the data contained in the financial statements of Taiwanese banks. They use this data to make advanced predictions of the performances of 24 commercial banks in Taiwan. Pille and Paradi (2002) analyze the financial performance of Ontario credit unions. They develop models to detect weaknesses in Credit Unions in Ontario, Canada. Yasar and McCure (1996) use data envelopment analysis for measuring and assessing the financial performance for hospitals. They compute a financial performance index (FPI) as a measure of aggregate financial performance. They show that financial performance index across many financial ratios eases the comparison of an individual hospital with its peers. Halkos and Salamouis (2004) explore the efficiency of Greek banks with the use of a number of suggested financial efficiency ratios for the time period 1997-1999. They show that data envelopment analysis can be used as either an alternative or complement to ratio analysis for the evaluation of an organization's performance. The study finds that the higher the size of total assets the higher the efficiency. Neal (2004) investigates X-efficiency and productivity change in Australian banking between 1995 and 1999 using data envelopment analysis and Malmquist productivity indexes. It differs from earlier studies by examining efficiency by bank type, and finds that regional banks are less efficient than other bank types. The study concludes that diseconomies of scale set in very early, and hence are not a sufficient basis on which to allow mergers between large banks to proceed. Paradi and Schaffnit (2004) evaluate the performance of the commercial branches of a large Canadian bank using data envelopment analysis. Chen, Sun, and Peng (2005) study the efficiency and productivity growth of commercial banks in Taiwan before and after financial holding corporations' establishment. They employ a data envelopment analysis approach to generate efficiency indices as well as Malmquist productivity growth indices for each bank. Howland and Rowse (2006) assess the efficiency of branches of a major Canadian bank by benchmarking them against the DEA model of American bank branch efficiency. Sufian (2007) uses DEA approach to evaluate trends in the efficiency of the Singapore banking sector. The paper uses DEA approach to distinguish between technical, pure technical and scale efficiencies. Sanjeev (2007) evaluates the efficiency of the public sector banks operating in India for a period of five years (1997-2001) using DEA. The study also investigates if there is any relationship between the efficiency and size of the banks. The results of the study suggest that no conclusive relationship can be established between the efficiency and size of the banks. Lin, Shu, and Hsiao (2007) study the relative efficiency of management in the Taiwanese banking system through DEA. The goal is to estimate the competitiveness of each bank and managerial efficiency is to show the efficiency variation of each bank through Malmquist index. Bergendahl and Lindblom (2008) develop principles for an evaluation of the efficiency of a savings bank using data envelopment analysis as a method to consider the service orientation of savings

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banks. They determine the number of Swedish savings banks being “service efficient” as well as the average degree of service efficiency in this industry. Hoon and Chunyan (1994) analyzed the productive efficiency of the railway services in 19 Organization for Economic Cooperation and Development (OECD) countries. They report that railway systems with high dependence on public subsidies are less efficient than similar railways with less dependence on subsidies. Cowie and Riddington (1996) evaluate the efficiency of the European railways through the use of a production frontier approach. Yu and Lin (2008) uses a multi-activity network DEA model to simultaneously estimate passenger and freight technical efficiency, service effectiveness, and technical effectiveness for 20 selected railways for the year 2002. Lozano & Gutierrez (2011) illustrate the slacks-based measure of efficiency of 39 Spanish airports using DEA. Liu & Liu (2010) illustrate the use of DEA in evaluating and ranking the research and redevelopment performance of Taiwan’s government-supported research institutes. Saranga & Moser (2010) develop a comprehensive performance measurement framework using the classical and two-stage Value Chain Data Envelopment Analysis model.

Sellers-Rubio and Mas-Ruiz (2006) examined the efficiency of supermarket chains in the Spanish retailing industry using DEA. The study evaluated the 100 supermarket chains between 1995 and 2001 revealing that there were “high levels of economic inefficiency in the Spanish retailing industry” (Sellers-Rubio and Mas-Ruiz, 2006). The study found that the “underlying causes of the difference between the current performance level of an organization and the best practically possible level are management style, organizational structure, and product quality among others” (Sellers-Rubio and Mas-Ruiz, 2006). Donthu and Yoo (1998) measured the relative-to-best performance efficiency of retail outlets characterized by multiple inputs and outputs using data collected from retail stores belonging to a restaurant chain. The greatest advantage of using DEA to evaluate performance efficiency is that a retail outlet is compared to the best performing retail outlets, otherwise known as benchmarking. Through benchmarking, retail outlets of a chain store or a franchise system can be comparatively evaluated for performance, ultimately improving the operation of the entire retail store. Jiang and Talaga (2006) used DEA to explore the relationship between satisfying customers and building a customer base for the e-tailing industry. The study found that “performance scores for developing a customer base vary across product categories” (Pingjun and Talaga, 2006), and “performance score is a good parameter for predicting future change on a unique number of visitors and on the competition pattern for a particular e-tailer” (Pingjun and Talaga, 2006). This study used DEA to help e-tailers “measure the reach efficiency which is the extent to which the e-tailer is attracting visitors within an online environment and page-view efficiency measures the performance of an e-store in generating more page view per visitor” (Pingjun and Talaga, 2006). By simultaneously getting more visitors to an e-tailer’s web site and having them stay longer is reflected in the overall efficiency of the unit (Pingjun and Talaga, 2006). Barth (2007) used DEA to show that “new-style retail wine stores with features such as tasting rooms, lecture theatres, and demonstration kitchens used to educate and engage customers have better retail efficiency than old-style stores”. The DEA used “sales dollars, labour hours, and litres of inventory depletion from a paired-sample of old-style and new-style facilities to determine the retail efficiency of the stores” (Barth, 2007). The results of the study reflected that the new-style stores had higher retail efficiency than the old style stores and reducing the input in the older stores does not increase the retail efficiency of these stores. Although the study shows that the retail efficiency is increased with the new store features, the contribution of each feature towards the overall improvement in retail performance is unknown (Barth, 2007). Athanassopoulos and Thanassoulis (1995) used DEA to assess the market efficiency of pubs in the UK to aid in planning. Market efficiency is defined as “the extent to which a unit is exploiting the potential within its catchment area for generating revenue (Athanassopoulos and Thanassoulis, 1995). The inputs are environmental variables as well as one uncontrollable internal variable and the output is the revenue generated (Athanassopoulos and Thanassoulis, 1995). Pilling, et al (1999) used to adjust salesperson performance for territory characteristics in order to give a more individualized and complete picture of salesperson performance. DEA helped adjust for territory inequities in the evaluation process and identified best practices among a group of salespeople as well as included ways to increase the impact of sales-force related expenditures (Pilling, et al, 1999).

Murthi, Choi, & Desai (1997) examine the market efficiency of the mutual fund industry by different investment objectives. They use a benefit/cost non-parametric analysis where a relationship between return (benefit) and expense ratio, turnover, risk, and loads (cost) is established. They also develop a measure of performance of mutual funds that has a number of advantages over traditional indices. The DEA portfolio efficiency index (DEPI) does not require specification of a benchmark, but incorporates transaction costs. The most important advantage of DEA method as compared to other measures of fund performance is that DEA identifies the variables leading to inefficiencies and the levels by which they should be changed to restore the fund to its optimum level of efficiency. McMullen and Strong (1998) applied DEA to evaluate the relative performance of 135 US common stock funds using one, three, and five-year annualized returns, standard deviation of returns, sales charge, minimum initial investment, and expense ratio. They illustrate that DEA can assist in selecting mutual funds for an investor with a multifactor utility function. The DEA selects optimum combinations of investment characteristics, even when the desired characteristics are other than the two-factors specified in Capital Market Theory. The DEA enable the user to determine the most desirable alternatives, and pinpoint the inefficiencies in a DEA-inefficient alternative. Sedzro and Sardano (1999) analyzed 58 US equity funds in Canada using DEA with annual return, expense ratio, minimum initial investment and a proxy for risk as factors associated with fund performance. Further, they also find a strong relationship among the efficiency rankings using DEA, Sharpe ratios, and Morningstar data. Galagedera and Silvapulle (2002) use DEA to measure the relative efficiency of 257 Australian mutual funds. The further investigate the sensitivity of DEA.
efficiency to various input-output variable combinations. They find that more funds are efficient when DEA captures a fund’s long-term growth and income distribution than a shorter time horizon. In general, the overall technical efficiency and the scale efficiency are higher for risk-averse funds with high positive net flow of assets.

Haslem and Scheraga (2003) use DEA to identify efficiencies in the large-cap mutual funds in the 1999 Morningstar 500. They identify the financial variables that differ significantly between efficient and inefficient funds, and determine the nature of the relationships. They use Sharpe index as the DEA output variable. They find that the input/output and profile variables are significantly different between the Morningstar 500 (1999) large-cap mutual funds that are DEA performance-efficient and inefficient. Basso and Funari (2001) propose the use of DEA methodology to evaluate the performance of mutual funds. The proposed DEA performance indexes for mutual funds represent a generalization of various traditional numerical indexes that can take into account several inputs and outputs. They propose two classes of DEA indexes. The first class generalizes the traditional measures of evaluation using different risk indicators and subscription and redemption costs that burden the fund investment. The second class of indexes considers a multiple inputs-outputs structure. Thus, they monitor not only the mean return but also other features such as stochastic dominance and the time lay-out. Morey and Morey (1999) present two basic quadratic programming approaches for identifying those funds that are strictly dominated, regardless of the weightings on different time horizons being considered, relative to their mean returns and risks. They present a novel application of the philosophy of data envelopment analysis that focuses on estimating “radial” contraction/expansion potentials. Furthermore, in contrast to many studies of mutual fund’s performance, their approach endogenously determines a custom-tailored benchmark portfolio to which each mutual fund’s performance is compared. Feroz, Kim, and Raad (2003) illustrate the use of data envelopment analysis to evaluate the financial performance of oil and gas industry. Edirisingehe and Zhang (2007) develop a data envelopment analysis model to evaluate a firm’s financial statements over time in order to determine a relative financial strength indicator that can predict firm’s stock price returns.

Studies combining DEA and Neuro-fuzzy models:

Recently, some studies have proposed the fusion or joint modeling of DEA models and fuzzy logic. Omero, et al. (2005) illustrate the development of a decision support system that uses DEA for qualitative data analysis. The system uses fuzzy logic to integrate heterogeneous data from multiple sources. Triantis (2003) propose a fuzzy DEA approach that computes fuzzy non-radial technical efficiency measures and implements the approach for a newspaper preprint insertion manufacturing process. Wu (2009) proposes an integrated approach to rate decision alternatives using data envelopment analysis and preference relations in three stages. First, pair wise efficiency scores are computed using two DEA models: the CCR model and the proposed cross-evaluation DEA model. Second, the pair wise efficiency scores are then utilized to construct the fuzzy preference relation and the consistent fuzzy-preference relation. Third, by use of the row wise summation technique, the study yields a priority vector that is used to rank decision-making units. Zeydan et al. (2009) illustrate a new framework that combines fuzzy TOPSIS (technique for order preference by similarity to ideal solution) to measure qualitative performance and DEA to measure quantitative performance. Hougaard (1999) suggests extending technical efficiency scores of DEA models to fuzzy scores that enable the decision maker to use scores of technical efficiency in combination with other sources of available performance e.g. expert opinions, key figures, etc. In addition, many researchers have developed models to combine fuzzy logic and DEA to handle imprecise or vague data. Sengupta (1992) utilized the probabilistic feasibility of the inequality constraints to propose a fuzzy approach and use a fuzzy linear programming transformation approach as a viable approach. Many researchers have proposed fuzzy mathematical programming approaches such as probabilistic programming and alpha-cut approaches to assess the relative efficiency of the DMUs (Guo & Tanaka, 2001; Lertworasirikul, Fang, Joines, & Nuttle, 2003; Leon, Liern, Ruiz, & Sirvent, 2003; Saati, Memariani & Jahanshahahloo, 2002). Lertworasirikul et al. (2003) propose a possibility approach to the treatment of fuzzy DEA models. Guo & Tanaka (2001) introduce an alpha-cut approach that changes a fuzzy DEA model to a bi-level LP model. Kao & Liu (2000) propose a technique to transform a fuzzy DEA model into a family of crisp DEA models by applying the alpha-cut approach. They solve multiple LP problems to approximate the membership function of the efficiency score to assess a DMU. Liu (2008) developed a fuzzy DEA model to find the efficiency measures embedded with the assurance region concept. Shokouhi et al. (2010) propose a robust optimization method to deal with data uncertainties that cover the interval approach DEA results with fuzzy DEA approach. Ma & Li (2008) propose a methodology to incorporate fuzzy preferences and range reduction techniques. The study first adopts a modified DEA model to generate reasonable upper and lower bounds of preference ratios. By referring to these ranges, a decision maker then specifies his/her preferences partially. Qin & Liu (2010) present several formulas for mean chance distributions of triangular fuzzy random variables and their functions to develop a new class of fuzzy random data envelopment analysis models. Kao & Liu (2003) use maximizing and minimizing set methods to rank the fuzzy efficiency scores without knowing the exact form of the membership function.

As illustrated above, all of these studies illustrate the merger of fuzzy logic and DEA to develop fuzzy DEA models. None of the studies illustrate the use of DEA models and fuzzy logic to form DEANFIS model, in this order. Therefore, the purpose of this study is twofold. Firstly, this study investigates and analyzes the synergy of DEA and ANFIS models theoretically to develop DEANFIS models. The study further plans to use simulated data to validate the models. Secondly, this study aims to use industry data to design decision support system that can provide rules to the manager to make decisions.
METHODOLOGY

The Data Envelopment Analysis Model

The Data Envelopment Analysis (DEA) (Charnes et al., 1978) is a widely used optimization-based technique that measures the relative performance of decision making units that are characterized by a multiple objectives and/or multiple inputs structure. Data envelopment analysis is a technique used to assess the comparative efficiency of homogenous operating units such as schools, hospitals, utility companies, sales outlets, prisons, and military operations. More recently, it has been applied to banks (Haslem, Scheraga, & Bedingfield, 1999) and mutual funds (Haslem & Scheraga, 2003; Galagedera & Silvakulpe, 2002; McMullen & Strong, 1998; Murthi, Choi, & Desai, 1997). It is a powerful technique for measuring performance because of its objectivity and ability to handle multiple inputs and outputs that can be measured in different units. The DEA approach does not require specification of any functional relationship between inputs and outputs, or a priori specification of weights of inputs and outputs. DEA provides gross efficiency scores based on the effect of controllable and uncontrollable factors.

The DEA methodology measures the performance efficiency of organization units called Decision-Making Units (DMUs). This technique aims to measure how efficiently a DMU uses the resources available to generate a set of outputs. The performance of DMUs is assessed in DEA using the concept of efficiency or productivity defined as a ratio of total outputs to total inputs. Efficiencies estimated using DEA are relative, that is, relative to the best performing DMU or DMUs (if multiple DMUs are the most efficient). The most efficient DMU is assigned an efficiency score of unity or 100 percent, and the performance of other DMUs vary between 0 and 100 percent relative to the best performance.

Neuro-Fuzzy Inference System Model:

Fuzzy logic starts with the concept of fuzzy sets. Fuzzy sets describe vague concepts. A fuzzy set admits the possibility of partial membership in it. The degree to which an object belongs to a fuzzy set is denoted by a membership function between 0 and 1. A membership function is a curve that describes how each point in the input space is mapped to a membership value (or degree of membership) between 0 and 1. Fuzzy logic is a convenient way to map an input space to an output space through the primary mechanism of IF-THEN statements called rules.

The input space for the mapping is input parameters and the output space is the decision variables. For instance, the decision maker is advised to accept or reject a proposition or point out the extent of risk involved. Typically, a fuzzy inference system interprets the values of an input vector and, based on some set of rules, assigns values to the output. Fuzzy inference is the process of formulating the mapping from a given input to an output using fuzzy logic. The mapping then provides a basis from which decisions can be made, or patterns discerned.

Neural fuzzy systems aim at providing fuzzy systems with the kind of automatic tuning methods typical of neural networks but without altering their functionality. In neural fuzzy systems, neural networks are used in augmenting numerical processing of fuzzy sets that is utilized as fuzzy rules. Thus, the fuzzy rule-based modeling process devises a logical approach to imitate the process of human decision making using uncertain information. Neural networks calibrate the model structure to get the optimal model. Neurofuzzy computing optimizes the premise and consequent parameters of the fuzzy inference system using available data. Figure 1 provides a layout of a Neuro-Fuzzy System.

As illustrated in Figure 1, ANFIS takes a fuzzy inference system and tunes it with a backpropagation algorithm based on some collection of input-output data. This allows the fuzzy system to learn. A network structure facilitates the computation of the gradient vector for parameters in a fuzzy inference system. These techniques provide a method for the fuzzy modeling procedure to learn information about a data set, in order to compute the membership function parameters that best allow the associated fuzzy inference system to track the given the input/output data. The learning method works similar to that of the neural networks.

A fuzzy inference system works in five steps: fuzzify inputs, apply fuzzy indicator, apply implication method, aggregate all outputs, and defuzzify the output. The first step is to take the inputs and determine the degree to which they belong to each of the appropriate fuzzy sets via membership functions. The input values are always crisp numerical independent variables that measure the operation of the fuzzy system. These crisp variables are then fuzzified via a membership function that computes the measure of belief in the fuzzy indicator. Once all of the inputs have been fuzzified, the inference system combines the fuzzy indicators in ways described by the fuzzy rules in the system. Each fuzzy rule then produces an output value that indicates the measure of certainty in the inferred value. For all rules that produce outputs that relate to the same measure, the centroid of the clipped, fuzzy-membership functions is determined and used to defuzzify the output. This process occurs for all outputs generated by the system.

Illustrating DEANFIS model of the Decision Support System for Loan Evaluation

To screen consumer loan applications, loan officers use different methods besides intuitive judgment and experience. Using mathematical techniques, many credit-scoring models have been developed to assist the loan officer in differentiating good loans from bad. Besides these traditional statistical models, many financial institutions use artificial intelligence methods, such as expert systems, artificial neural systems, and fuzzy logic. It is only recently that the finance community has started applying data envelopment analysis, a relatively new technique. This study proposes to assess the creditworthiness of a new loan applicant using a decision support system that applies a combination of two diverse analytical techniques: data envelopment analysis and neuro-fuzzy models. I propose to use the Data Envelopment Analysis methodology to assess the creditworthiness of an existing set of loans whose outcome (accepted and turned good, accepted and turned bad, and reject) is known. The DEA model benchmarks the given set of loans, and assigns an efficiency score. Further, using the relative efficiency score (generated by the DEA model) and other loan characteristics
the neuro-fuzzy model can create rules that identify the major characteristics of loans that are not likely to default. Each of the loans is a homogenous unit, and we can apply the DEA methodology to assess comparative performance of these loans. The DEA model is a part of a decision support system that uses a number of variables to determine how good a loan is. A loan application includes information such as the applicant’s age, housing, address time, total income, number of credit cards, number of dependents, job time, other loan obligations, total debt, monthly rent/mortgage payments, number of inquiries for an applicant, and credit rating. The study proposes to create a DEA model that evaluates the relative efficiency of a set of loans that credit unions have already administered, and allocates a score on the scale of 1 to 100. Further, the next step in the design of the decision support system is to develop a neuro-fuzzy model of the quality of loans analyzed by the DEA model. Artificial neural systems and fuzzy logic are artificial intelligence techniques that function on the same lines as human intelligence. Fuzzy logic is a rule-based development in artificial intelligence that tolerates imprecision and uses it to solve problems. Fuzzy sets and fuzzy logic systems work the same way the brain deals with inexact information. On the other hand, neural networks are modeled after the physical architecture of the brain. Neural networks are specialized hardware or software that emulates the processing patterns of the biological brain. Fuzzy logic and neural networks are complementary technologies in the design of intelligent systems. Each method has merits and demerits. Artificial neural systems suffer from their inability to explain the steps used to make decisions and incorporate rules in their architecture. Neural fuzzy systems address some of the shortcomings of artificial neural network tools. Fuzzy logic techniques often deal with issues such as reasoning on a higher level than neural networks. However, since fuzzy systems do not have much learning capability, it is difficult for a human operator to tune the fuzzy rules and membership functions from the training data set. Thus, to reap the benefits of both fuzzy systems and neural networks, a promising approach is to merge fuzzy logic and neural networks into an integrating system. Neural fuzzy systems represent one of the ways in which fuzzy systems and neural networks can be merged. Using a pooled data set of twelve credit unions, this study will design and develop a decision support system (using the combination of DEA and neuro-fuzzy models) to differentiate between “good” loans and potential “bad” loans. Further, the decision support system will also explain why a loan is a bad loan.

Data Specifications:
The data for this study is a pooled data set of loans made by nine different credit unions with a total of 790 loans. The applicants can be categorized into three major groups: applicants who were accepted, and were good credits (Group 1); applicants who were accepted, but were not good credits (Group 2); and applicants who applied for a loan, but were rejected (Group 3). Further, the data set also includes information such as the applicant’s age, housing, address time, total income, number of credit cards, number of dependents, job time, co-maker on other loans, total debt, monthly rent/mortgage payments, number of inquiries for an applicant, and credit rating of each applicant. Credit unions in the data set assign loan applicants into four credit groups—excellent (1), good (2), marginal (3), and poor (4). The credit rating is determined on the basis of the number of inquiries. The higher the number of inquiries on an applicant, the lower will be the credit rating. The calculation of credit ratings is consistent across all the credit unions. Thus, based on the information supplied by an applicant, we can calculate the applicant’s total payments, total income, and total debt.

The study will consider the following variables:

- Total Debt: Total debt of the applicant at the time of application.
- Number of Loans: Total number of loans outstanding in the applicant’s name.
- Payments: Total monthly payments
- Dependents: No of dependents of the applicants.
- Total Income: Total monthly income from all sources.
- Job time: Time at current employer.

To evaluate the effectiveness of neuro-fuzzy systems to differentiate between good and bad credit, we use applicant’s total income, total payments, total debt, and DEA efficiency score as the input variables. Further, we calculate the ratio of total payments to total income, and ratio of the applicant’s total debt to total income.3 If the ratio of total payment to the total income of the applicant is high, the risk of loss due to default by the borrower is high. Similarly, the higher the ratio of total debt to the total income of the applicant, the higher will be the applicant’s credit risk. On the other hand, low ratios of total payment to total income and total debt to total income are indicative of a good credit applicant. Besides these two ratios, the DEA efficiency score also reflects the creditworthiness of a loan applicant. Therefore, we use three input variables: the ratio of the total payment to the total income (ratio 1), the ratio of debt to the total income (ratio 2), and the DEA efficiency score (calculated credit rating) of the applicant as the factors that can discriminate between a good and a bad loan.4

Data Envelopment Model Specifications for Loan

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1 The fusion of fuzzy logic and neural networks can be realized in three directions, resulting in systems with different characteristics: Neural Fuzzy Systems, Fuzzy Neural Networks, and Fuzzy-neural Hybrid Systems.

2 The data set includes loans made by the following nine credit unions: 1. Jefferson County Teachers Credit Union; 2. Jefferson County Employees Credit Union; 3. Family Security Credit Union; 5. Etowah Steel Workers Credit Union; 6. Washington Hill Federal Credit Union; 7. Riverdale Credit Union; 8. Delchamp Credit Union; 9. Lister Hill Credit Union.

3 Total payments include payments for rent, automobile loan, debt, and other payments. Total income includes income from all sources.

4 According to Fabozzi, in a mortgage loan, banks and financial institutions consider the ratio of total payments to the total income and the ratio of debt to the total income of the applicant. Since consumer loans are somewhat similar in nature, we use these ratios to discriminate between good and bad credit risk. See Fabozzi (1996).
Evaluation

In this study, the analysis of a loan emphasizes inputs and outputs. Therefore, I select the multiplier model for my analysis. In addition, factors such as total debt, number of loans, total payments, number of dependants, total income, and time spent in employment are not very flexible inputs that cannot be immediately controlled. Therefore, output-based formulation is recommended for my study. Furthermore, the quality of the loans does not depend on the scale of operations, thus variable returns to scale is safe assumption. Also, the structure of the DEA model (in multiplier form) uses an equation and separate calculation for every input and output. Therefore, all the input and output variables can be used simultaneously and measured in their own units.

Neuro-Fuzzy Model for the Decision Support System

For the neuro-fuzzy model, I use three input variables: the ratio of the total payment to the total income (ratio 1), the ratio of debt to the total income (ratio 2), and the DEA efficiency score (calculated credit rating) of the applicant as the factors that can discriminate between a good and a bad loan. As mentioned above, the neuro-fuzzy model works in two stages: training and testing. To adequately train the network, the training sample should be a good representative of the population under study. Thus, the training data should cover the entire expected input data space. Further, the network should not be trained completely with input vectors of one class, and then switched to another class; the network will forget the original training. Thus, in accordance with these guidelines, the network should be trained with a sample of 500 observations. The training set is an unbiased sample with data points from all the three classes. Further, to ensure that the training data covered the entire input space (i.e. learn different characteristics of the applications accepted and rejected), observations were selected from all the credit unions. This would prevent the network from learning the characteristics of only one credit union, which can be misleading. Moreover, to ensure that the network is not trained with vectors from one class or one single credit union, the observations should be intermingled randomly. Finally, as there are no preferable membership functions, I will create an initial set of membership functions using grid partition method. The built-in function genfis 1 of the fuzzy logic toolbox of the MATLAB software will be used to create the initial membership function matrix.

CONTRIBUTION OF THE STUDY

This study proposes the modeling and development of a decision support system that uses a combination of data envelopment analysis and neuro-fuzzy systems. Thus, the decision support system derives benefit from both methodologies to recommend a decision. As illustrated in the literature review section, many studies illustrate the use of fuzzy systems and DEA. However, very few studies illustrate the fusion of DEA and ANFIS models. In addition, all the studies illustrate fuzzy DEA models (using fuzzy logic and DEA model). This study proposes the design and modeling of DEANFIS model (using DEA and ANFIS model) to develop a multidimensional decision support system that can benefit from both the techniques.

DEA does not require the manager to attach prescribed weights to each input and output. Moreover, DEA modeling does not require prescription of the functional forms that are needed in statistical regression approaches. DEA uses techniques such as mathematical programming that can handle a large number of variables and constraints. As DEA does not impose a limit on the number of input and output variables to be used in calculating the desired evaluation measures, it’s easier for managers to deal with complex problems and other considerations they are likely to confront. DEA identifies good units in a given set of DMUs and provides a measure of inefficiency for all others. The DMUs having the most desirable characteristics are rated a score of one (100% efficient), while the DMUs that are inefficient score between zero and one. DEA methodology can identify a bad DMU by comparing its characteristics with a given set of benchmark DMUs having good DMU characteristics. Similarly, neuro-fuzzy models do not require restrictive assumptions of the statistical model. Fuzzy logic provides a means of combining symbolic and numeric computations in inference processing. The linkage between neural networks and symbolic reasoning can be established through the membership function of fuzzy logic. The membership function measures the degree of possibility of a concept as related to a numeric quantity. A neural network can be used to synthesize a membership function by training it with instances of the relation. Neuro-Fuzzy systems provide flexibility to the decision-maker to incorporate their own rules in the DEA model to assess DMUs.

FIGURES, TABLES, & REFERENCES

Available upon request from the author.
ON EFFECTIVENESS OF TWO REVERSE AUCTION PROCUREMENT MODELS FOR MULTIPLE BUYERS

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ABSTRACT

Combinatorial reverse auction is a popular business model for procurement. If there are multiple buyers, the buyers may either hold multiple combinatorial reverse auctions independently. Alternatively, the buyers may delegate the auction to a group buyer who holds only one combinatorial reverse auction on behalf of all the buyers. In the existing literature, there is still a lack of comparative study on the efficiency of the aforementioned two different procurement models for multiple buyers. The goal of this paper is to study the effectiveness of these two different combinatorial reverse auction models. We first formulate the problems for these two combinatorial reverse auction models and then compare the performance as well as the computational efficiency for these two combinatorial reverse auction models. Our analysis indicates that the group-buying combinatorial reverse auction model outperforms multiple independent combinatorial reverse auctions not only in efficiency but also in performance.

Keywords: Business model, Procurement, Auction

1. INTRODUCTION

Reverse auction is a popular business model that can be applied in corporations’ procurement. Combinatorial reverse auction [7][25][32][34] enables a buyer to purchase multiple goods with the lowest prices from the sellers. Applying combinatorial reverse auctions in corporations’ procurement processes can lead to significant savings [16][26][27]. In real world, multiple buyers may procure goods at the same time. If there are multiple buyers, group-buying may be applied to reduce the costs and benefit the buyers [17]. Group-buying is a popular business model employed by many companies in practice. The rationale of group-buying is due to demand aggregation, which benefits sellers, offering lower marketing costs and coordinated distribution channels, as well as buyers, who enjoy lower costs for product purchases [6]. From the perspective of buyers, quantity based discounts provide a huge incentive to form coalitions and take advantage of lower prices without ordering more than their actual demand. An interesting issue is to develop a business model for supporting multiple buyers’ procurement by combining the concept of group-buying with combinatorial reverse auctions.

In existing literature, combinatorial auctions and group-buying have attracted considerable attention recently. An excellent survey on combinatorial auctions can be found in [5] and [28]. Combinatorial auctions [1] are notoriously difficult to solve from a computational point of view [30] due to the exponential growth of the number of combinations [18]. The combinatorial auction problem can be modeled as a set packing problem (SPP) [3][8][13][33]. Sandholm et al. mentions that determining the winners so as to maximize revenue in combinatorial auction is NP-complete [31][32]. Exact algorithms have been developed for the SPP problem, including iterative deepening A* search [31] and the direct application of available CPLEX IP solver [3]. Gonen and Lehmann proposed branch and bound heuristics for finding optimal solutions for multi-unit combinatorial auctions [10]. Jones and Koehler studied combinatorial auctions using rule-based bids [19]. In [11][14][15][16], the authors proposed a Lagrangian heuristic and a Lagrangian relaxation approach for combinatorial reverse auction problems.

There are also studies on group-buying in existing literature. Kauffman and Wang [20][21] examine group-buying as a dynamic pricing mechanism. They offer valuable insights for distributed group-buying mechanisms under uniform cost sharing. Chen et al. [4] analyze buyers’ bidding strategies in a group-buying auction considering limited supply of an item and private information of buyers. Anand and Aron [2] analyze the value of group-buying and the optimal price curve from a seller’s perspective. Cuihong Li, Katia Sycara and Alan Scheller-Wolf [24] introduce the concept of combinatorial coalition formation, which allows buyers to announce reserve prices for combinations of items. These reserve prices, along with the sellers’ price-quantity curves for each item, are used to determine the formation of buying groups for each item. The objective is to maximize buyers’ total surplus. Despite the aforementioned results on group-buying, there is still a lack of study on assessing the benefits and effectiveness of combining group-buying mechanism with combinatorial reverse auctions in multiple buyers’ procurement.

In this paper, we study two different business models for multiple buyers’ procurement based on combinatorial reverse auctions: (1) independent combinatorial reverse auctions: each buyer may hold a combinatorial reverse auction independently and (2) combinatorial reverse auctions based on group buying: multiple buyers delegate the auction to a group buyer and the group buyer holds only one combinatorial reverse auction for all the buyers. In developing an effective tool to support the decision of multiple buyers’ procurement, a comparative study on the performance and efficiency of the two aforementioned business models is needed. This motivates us to study the effectiveness of these two different combinatorial auction models, including performance and efficiency.

To compare the effectiveness of the aforementioned two combinatorial reverse auction models, we first illustrate the advantage of combining group-buying with combinatorial reverse auctions by an example. We then formulate the problems for these two combinatorial reverse auction models and propose solution algorithms for these two problems. For the two combinatorial reverse auctions, we formulate the
corresponding winner determination problems. As the two winner determination problems are NP Complete, we adopt a Lagrangian relaxation approach to developing solution algorithms for finding approximate solutions. Based on the proposed algorithms for the two problems, we compare the performance as well as the computational efficiency for these two combinatorial reverse auction models. Our analysis indicates that combinatorial reverse auction with group-buying not only outperforms multiple independent combinatorial reverse auctions but also is more efficient than multiple independent combinatorial reverse auctions.

This paper is different from the previous study on single buyer’s combinatorial reverse auction in [16] as it focuses on comparative study of two combinatorial reverse auction models for multiple buyers. The remainder of this paper is organized as follows. In Section 2, we first illustrate the advantage of group buying combinatorial reverse auction over multiple independent combinatorial reverse auctions by an example. In Section 3, we formulate the optimization problems for the aforementioned combinatorial reverse auction models and study the property of the solutions for the two problems. We propose the solution algorithms in Section 4. In Section 5, we study the efficiency of the two business model. Theoretical lower and upper bounds on the achievable reduction in cost are derived. We also compare the performance of the two combinatorial reverse auction models based on the results of numerical examples. We conclude this paper in Section 6.

2. MEETING BUYERS’ REQUIREMENTS WITH COMBINATORIAL REVERSE AUCTIONS

In this section, we illustrate different ways to meet multiple buyers’ requirements with combinatorial reverse auctions. We introduce two different combinatorial reverse auction models. In the first model, each buyer holds a combinatorial reverse auction independently. The solution that meets all the buyers’ requirements can be obtained by solving \( N \) combinatorial reverse auction subproblems. Each subproblem is solved by applying any existing combinatorial reverse auction algorithm. In the second model, a virtual group buyer is created. The group buyer’s requirements consolidate all the buyers’ requirements. The bids placed by the potential bidders in the first model are regarded as the bids placed to the group buyer. The solution that meets the group buyer’s requirements (and hence all the buyers’ requirements) is found by solving the combinatorial reverse auction subproblem for the group buyer.

Consider an application scenario in which Buyer 1 wants to purchase at least a bundle of items 1A, 1B and 1C from the market and Buyer 2 wants to purchase a bundle of items 1C and 1D.

Buyer 1 and Buyer 2 may apply acquire the desired items based on combinatorial reverse auction using two different business models.

Model 1: Buyer 1 and Buyer 2 hold two independent combinatorial reverse auctions. Suppose there are four bidders, Seller 1, Seller 2, Seller 3 and Seller 4 who place bids in the system. Suppose Seller 1 places the bid \((1A, 1C, p1)\) on Buyer 1, where \(p1\) denotes the prices of the bid. Seller 2 places the bid \((1B, 1C, p2)\) on Buyer 1. Seller 3 places the bid \((1D, p3)\) on Buyer 2. Seller 4 places the bid \((1C, 1D, p4)\) on Buyer 2. We assume that all the bids entered the auction are recorded. A bid is said to be active if it is in the solution. We assume that there is only one bid active for all the bids placed by the same bidder. For this example, the solution for this combinatorial reverse auction problem is \(\text{Seller 1: } (1A, 1C, p1)\), \(\text{Seller 2: } (1B, 1C, p2)\) and \(\text{Seller 4: } (1C, 1D, p4)\). The overall cost of this solution is \(p1+p2+p4\).

Model 2: Buyer 1 and Buyer 2 delegate the procurement to a group buyer that holds only one combinatorial reverse auction. In this business model, the group buyer consolidates all the requirements of Buyer 1 and Buyer 2 and holds only one combinatorial reverse auction. Suppose there are four bidders, Seller 1, Seller 2, Seller 3 and Seller 4 who place bids on the Group Buyer. Suppose Seller 1 places the bid: \((1A, 1C, p1)\), where \(p1\) denotes the prices of the bid. Seller 2 places the bid: \((1B, 1C, p2)\). Seller 3 places the bid: \((1D, p3)\). Seller 4 places the bid: \((1C, 1D, p4)\). We assume that all the bids entered the auction are recorded. A bid is said to be active if it is in the solution. We assume that there is only one bid active for all the bids placed by the same bidder. For this example, the solution for this combinatorial reverse auction problem depends on \(p3\) and \(p4\) as follows. If \(p3 \leq p4\), the winning bid is \(\text{Seller 1: } (1A, 1C, p1)\), \(\text{Seller 2: } (1B, 1C, p2)\) and \(\text{Seller 3: } (1D, p3)\). The overall cost of this solution is \(p1+p2+p3\), which is lower than that of Model 1 as \(p3 \leq p4\). If \(p3 > p4\), the winning bid is \(\text{Seller 1: } (1A, 1C, p1)\), \(\text{Seller 2: } (1B, 1C, p2)\) and \(\text{Seller 4: } (1C, 1D, p4)\). Then the overall cost of the solution of Model 2 is the same as that of Model 1. This example illustrates that the overall cost of the combinatorial reverse auction based on group buying is no greater than that of two independent combinatorial reverse auctions.

3. PROBLEM FORMULATION FOR TWO COMBINATORIAL REVERSE AUCTION MODELS

Motivated by the above examples, it is interesting to compare the two models of combinatorial reverse auction from the cost and computation aspects. In the remainder of this paper, we first formulate the problem and then propose solution methodology for these two problems. We then compare the time and computation time by numerical examples.

Model 1: Combinatorial Reverse Auction for a Single Buyer

Let \(I\) denote the number of buyers in a combinatorial auction. Each \(i \in \{1, 2, 3, ..., I\}\) represents a buyer. Consider a buyer \(i\) who requests a set of items to be purchased, where \(i \in \{1, 2, 3, ..., I\}\). Let \(K\) denote the number of items requested. Let \(d_{ij}\) denote the desired units of the \(k\)th item requested by buyer \(i\), where \(k \in \{1, 2, 3, ..., K\}\). In a combinatorial reverse auction, there are many bidders. Let \(N_i\) denote the set of bidders that take part in the combinatorial reverse auction of buyer \(i\). That is, each \(n \in N_i\) represents a bidder. To model the combinatorial reverse auction problem, the bid must be represented mathematically. We use a vector \(b_{nj} = (q_{n_{11}}, q_{n_{12}}, q_{n_{13}})\), for all \(j \in N_i\) to
represent the $j$-th bid submitted by bidder $n$, where $q_{njk}$ is a nonnegative integer that denotes the quantity of the $k$-th items and $p_{nj}$ is a real positive number that denotes the price of the bundle. As the quantity of the $k$-th items cannot exceed the quantity $d_k$, it follows that the constraint $0 \leq q_{njk} \leq d_k$ must be satisfied. The $j$-th bid $b_{nj}$ is actually an offer to deliver $q_{njk}$ units of items for each $k \in \{1,2,3,\ldots,K\}$ a total price of $p_{nj}$. Let $J_n$ denote the number of bids placed by bidder $n \in N$. Let $J$ denote the maximum number of bids that a bidder can place in each round of combinatorial reverse auction. That is, $J = \max J_n$.

To formulate the problem, we use the variable $x_{nj}$ to indicate the $j$-th bid placed by bidder $n$ is active ($x_{nj} = 1$) or inactive ($x_{nj} = 0$). The winner determination problem can be formulated as an Integer Programming problem as follows.

**Winner Determination Problem for Buyer $i$ (WDP- $i$):**

$$
\begin{align*}
\min & \sum_{n \in N_i} \sum_{j=1}^{J_n} x_{nj} p_{nj} \\
\text{s.t.} & \sum_{n \in N_j} q_{njk} \geq d_{ik} \quad \forall k \in \{1,2,\ldots,K\} \\
& x_{nj} \in \{0,1\}
\end{align*}
$$

Constraints ($a$) in WDP assumes “free disposal” as the total quantity offered by the winners must be greater than or equal to the desired quantity of the buyer. If there are more quantities provided than needed, we can dispose of the surplus with no additional cost.

**Model 2: Combinatorial Reverse Auction for Multiple Buyers based on Group Buying**

Consider a buyer who requests a set of items to be purchased. Let $K$ denote the number of items requested. Let $I$ denote the number of buyers in a combinatorial auction. Each $i \in \{1,2,3,\ldots,I\}$ represents a buyer. Let $d_{ik}$ denote the desired units of the $k$-th items, $k \in \{1,2,3,\ldots,K\}$. In a combinatorial reverse auction, there are many bidders to submit a tender. Let $N = \bigcup i N_i$ denote the set of bidders that take part in the combinatorial auction.

To model the combinatorial reverse auction problem, the bid must be represented mathematically. We use a vector $b_n = (q_{n1k}, q_{n2k}, q_{n3k}, \ldots, q_{nkK}, p_{nj})$ to represent the $j$-th bid submitted by bidder $n$, where $q_{njk}$ is a nonnegative integer that denotes the quantity of the $k$-th items and $p_{nj}$ is a real positive number that denotes the price of the bundle. As the quantity of the $k$-th items cannot exceed the quantity $d_{ik}$, it follows that the constraint $0 \leq q_{njk} \leq d_{ik}$ must be satisfied. The $j$-th bid $b_{nj}$ is actually an offer to deliver $q_{njk}$ units of items for each $k \in \{1,2,3,\ldots,K\}$ a total price of $p_{nj}$. Let $J_n$ denote the number of bids placed by bidder $n \in \{1,2,3,\ldots,N\}$. To formulate the problem, we use the variable $x_{nj}$ to indicate the $j$-th bid placed by bidder $n$ is active ($x_{nj} = 1$) or inactive ($x_{nj} = 0$). The winner determination problem can be formulated as an Integer Programming problem as follows.

**Winner Determination Problem for Group Buyer (WDP- $G$):**

$$
\begin{align*}
\min & \sum_{n \in N_i} \sum_{j=1}^{J_n} x_{nj} p_{nj} \\
\text{s.t.} & \sum_{n \in N_j} q_{njk} \geq \sum_{i=1}^{I} d_{ik} \quad \forall k \in \{1,2,\ldots,K\} \\
& x_{nj} \in \{0,1\}
\end{align*}
$$

Inequalities ($c$) of WDP- $G$ are the demand constraints that need to be satisfied by the solution.

To compare the performance of Model 1 and Model 2, we develop solution algorithms for them.

### 4. SOLUTION ALGORITHMS

One way to reduce the computational burden in solving the WDP is to adopt Lagrangian relaxation approach to set up a fictitious market to determine an allocation and prices in a decentralized way to adapt to dynamic environments where bidders and items may change from time to time. The buyer announces which sets of items and sets prices for them. If two or more agents compete for the same item, the buyer adjusts the price vector. This saves bidders from specifying their bids for every possible combination and the buyer from having to process each bid function. The bundle associated with the bid is tentatively assigned to that bidder only if the price of the bid is the lowest.

In this paper, we develop solution algorithms based on Lagrangian relaxation. The basic idea of Lagrangian relaxation is to relax some of the constraints of the original problem by moving them to the objective function with a penalty term. That is, infeasible solutions to the original problem are allowed, but they are penalized in the objective function in proportion to the amount of infeasibility. The constraints that are chosen to be relaxed are selected so that the optimization problem over the remaining set of constraints is in some sense easy. In WDP- $i$ , observe that the coupling among different operations is caused by the demand constraints ($a$). Let $\lambda$ denote the vector with $\lambda_i$ representing the Lagrangian multiplier for the $k$-th items. We define

$$
L_i(\lambda) = \sum_{k=1}^{K} \lambda_i d_{ik} + \sum_{n \in N_i} L_{in}(\lambda),
$$

with

---

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Our methodology for finding a near optimal solution of WDP consists of three parts: (1) an algorithm for solving subproblems, (2) a subgradient method for solving the dual problem and (3) a heuristic algorithm for finding a near-optimal feasible solution.

(1) Algorithm for solving subproblems

Given $\lambda$, the optimal solution to BS subproblem $L_n(\lambda)$ can be solved as follows.

Let $j^* = \text{arg min}_{j \in \{1,2,...,n\}} (P_{nj} - \sum_{k=1}^{K} \lambda_k q_{njk})$. The optimal solution to $L_n(\lambda)$ is as follows.

$$x_{nj} = \begin{cases} 
0 & \forall j \in \{1,2,...,n\} \setminus \{j^*\} \\
1 & \text{if } P_{nj} - \sum_{k=1}^{K} \lambda_k q_{njk} < 0 \\
0 & \text{if } P_{nj} - \sum_{k=1}^{K} \lambda_k q_{njk} \geq 0 
\end{cases}$$

(2) A subgradient method for solving the dual problem max $L_\infty(\lambda)$

Let $\lambda^l$ be the optimal solution to the subproblems for given Lagrange multipliers $\lambda^l$ of iteration $l$. We define the subgradient of $L_n(\lambda)$ as $g^l(k) = d_k - \sum_{n \in N} \sum_{j=1}^{J} x_{nj}^l q_{njk}$, where $k \in \{1,2,...,K\}$.

The subgradient method proposed by Polyak [9] is adopted to update $\lambda^l$ as follows

$$\lambda_k^{l+1} = \left\{ \begin{array}{ll} 
\lambda_k^l + \alpha^l g^l(k) & \text{if } \lambda_k^l + \alpha^l \lambda_k^l \geq 0; \\
0 & \text{otherwise.}
\end{array} \right.$$ 

where $\alpha^l = \frac{\bar{L} - L_i(\lambda)}{\sum_k g^l(k)^2}$, $0 \leq c \leq 2$ and $\bar{L}$ is an estimate of the optimal dual cost. The iteration step terminates if $\alpha^l$ is smaller than a threshold. Polyak proved that this method has a linear convergence rate.

The solution obtained by applying the subgradient method may not be a feasible. If it is not feasible, it could be adjusted to a feasible solution without a great increase in objective function value. To adjust the solution of the dual problem to a feasible one, one must identify the set of demand constraints violated $K^0$ and the set of bidders $I^0$ that is not a winner in solution of the dual problem. Then we pick the bidders from the set $I^0$ according to the rule of minimal cost first to fulfill the insufficient quantity required by the set of violated demand constraints $K^0$.

(3) Heuristic Algorithm for Finding a Feasible Solution

Step 0: $\overline{x}_{nj} \leftarrow x_{nj}^*$

Step 1: Find the set of demand constraints violated.

Find $K^0 = \{k \in \{1,2,3,...,K\}, \sum_{j=1}^{J} x_{nj}^* q_{njk} < d_k \}$.

Step 2: Find the set of bidders that is not a winner in solution $x^*$.

Find $N^0 = \{n | n \in N, x_{nj}^* = 0 \}$.

Step 3: While $K^0 \neq \Phi$

Select $k = \arg \min_{k \in K^0} \sum_{n \in N} \sum_{j=1}^{J} x_{nj}^* q_{njk}$ from $K^0$

Select $n \in N^0$ and $f \in \{1,2,...J_n\}$ with $j = \arg \min_{j \in \{1,2,...J_n\}, n_k > 0} P_{nj}$

Set $\overline{x}_{nj} = 1$

$N^0 \leftarrow N^0 \setminus \{n\}$

End While

The effectiveness of the solution algorithms can be evaluated based on the duality gap, which is the ratio of the difference between primal and dual objective values divided by the primal objective value. That is, duality gap of the solution for WDP - $i$ of buyer $i$ is defined by

$$\frac{f_i(\overline{x}_i) - L_i(\lambda^*)}{f_i(\overline{x}_i)} = \sum_{n \in N, j=1}^{J} \overline{x}_{nj} p_{nj} .$$

Let $L_i(\lambda^*) = \sum_{j=1}^{J} L_i(\lambda^*_j)$, $f_i(x^*_j) = \sum_{j=1}^{J} f_i(x^*_j)$ and $f_i(\overline{x}_i) = \sum_{j=1}^{J} f_i(\overline{x}_i)$. We have

$$L_i(\lambda^*) \leq f_i(x^*_j) \leq (e) .$$

By applying a similar procedure to WDP-G for Group Buyer. We define the following dual problem.

$$\max L(\lambda)$$

$$L(\lambda) = \sum_{k=1}^{K} \lambda_k \left( \sum_{i=1}^{J} d_i \right) + \sum_{n \in N} \sum_{j=1}^{J} L_{nj}(\lambda),$$

with

$$L_{nj}(\lambda) = \min x_{nj} \left( p_{nj} - \sum_{k=1}^{K} \lambda_k q_{njk} \right) \quad s.t. \quad x_{nj} \in \{0,1\}$$

The solution obtained by applying the subgradient method may not be a feasible. If it is not feasible, it could be adjusted to a feasible solution without a great increase in objective function value. To adjust the solution of the dual problem to a feasible one, one must identify the set of demand constraints violated $K^0$ and the set of bidders $I^0$ that is not a winner in solution of the dual problem. Then we pick the bidders from the set $I^0$ according to the rule of minimal cost first to fulfill the insufficient quantity required by the set of violated demand constraints $K^0$. 
bidder’s subproblems (BS). Our methodology for finding a near optimal solution of WDP consists of three parts as follows.

(1) An algorithm for solving subproblems

Given $\lambda$, the optimal solution to BS subproblem $L_{n_j}(\lambda)$ can be solved as follows.

$$x_{gnj} = \begin{cases} 1 & \text{if } P_{n_j} - \sum_{k=1}^{K} \lambda_k q_{njk} < 0 \\ 0 & \text{if } P_{n_j} - \sum_{k=1}^{K} \lambda_k q_{njk} \geq 0 \end{cases}$$

To make the set of $x_{gnj}$ is an estimate of the true values. Suppose that the solution $x^*$ is as follows. We define the relative bid $L_{n_j}(\lambda)$ of the group $g$ as follows:

$$L_{n_j}(\lambda) = \sum_{k=1}^{K} d_{ik} - \sum_{n \in N} \sum_{j=1}^{J} x_{gnj} p_{nj} \cdot$$

k = \arg \min_{k \in K} \sum_{i=1}^{I} d_{ik} - \sum_{n \in N} \sum_{j=1}^{J} x_{gnj} p_{nj} \cdot$$

The heuristic algorithm proceeds as follows to make constraint $k$ satisfied. Select $n \in N^0$ with $n = \arg \min_{n \in \{1,2,\ldots, N\}} p_{nj} > 0$ and set $x_{gnj} = 1$.

After performing the above operation, we set $N^0 \leftarrow N^0 \setminus \{n\}$. If the violation of the $k$-th constraint cannot be completely resolved, the same procedure repeats. Eventually, all the constraints will be satisfied. We use $x$ to denote the resulting feasible solution obtained from the above heuristics.

That is, duality gap of the solution for WDP-$G$ of the group buyer is defined by

$$f_g(x^*) - L(x^*) \cdot$$

with $f_g(x^*) = \sum_{n \in N} \sum_{j=1}^{J} x_{gnj} p_{nj} \cdot$

5. NUMERICAL RESULTS AND ANALYSIS

In this section, we will verify the benefit of group-buying mechanism. Based on the proposed algorithms, we compare the effectiveness of the two combinatorial reverse auction models by examples.

Example 1: Suppose there are four buyers, Buyer 1, Buyer 2, Buyer 3 and Buyer 4, who want to purchase the required goods by applying combinatorial reverse auctions. We compare Model 1 and Model 2 for this example as follows.

Model 1 for Example 1: Suppose Buyer 1, Buyer 2, Buyer 3 and Buyer 4 hold four combinatorial reverse auctions independently. There are ten bidders (sellers). The bids placed by the sellers are listed in Table 2 through Table 9. The data for Buyer 1’s combinatorial reverse auction are as follows:

- $N_1 = \{1,5\}$, $J = 2$, $K = 4$
- $d_{11} = 2, d_{12} = 2, d_{13} = 3, d_{14} = 1$

The four bids submitted by the two bidders are as follows:

- $q_{111} = 2, q_{112} = 2, q_{113} = 3, q_{114} = 0$
- $q_{311} = 0, q_{312} = 0, q_{313} = 0, q_{314} = 1$
- $q_{121} = 1, q_{122} = 1, q_{223} = 1, q_{224} = 0$
- $q_{521} = 0, q_{522} = 0, q_{523} = 0, q_{524} = 2$

$P_{11} = 140, \quad P_{51} = 36, \quad P_{12} = 63, \quad P_{22} = 83.$

By applying our algorithm, we find the solution: $x_{i12} = 0$, $x_{i11} = 1$, $x_{i22} = 0$.

The cost is: 176.

CPU time: 62.

The data for Buyer 2’s combinatorial reverse auction are as follows:

- $N_2 = 2, J = 2, K = 4$
- $d_{21} = 1, d_{22} = 2, d_{23} = 2, d_{24} = 3$

The four bids submitted by the two bidders are as follows:
The total cost of Model 1 is $f_j(\bar{x}_j) = 176 + 220 + 153 + 171 = 720$.

Model 2 for Example 1: A group buyer holds the combinatorial reverse auction for Buyer 1, Buyer 2, Buyer 3 and Buyer 4.

The data for Group Buyer’s combinatorial reverse auction are as follows:

$N = N_1 \cup N_2 \cup N_3 \cup N_4 = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$,

$J = 2, \ K = 4, \ I = 4$.

The twenty bids submitted by the ten bidders are as follows:

$q_{111} = 2, q_{112} = 2, q_{113} = 3, q_{114} = 0$,

$q_{211} = 0, q_{212} = 2, q_{213} = 0, q_{214} = 3$,

$q_{311} = 3, q_{312} = 3, q_{313} = 0, q_{314} = 1$,

$q_{411} = 1, q_{412} = 1, q_{413} = 3, q_{414} = 1$,

$q_{121} = 1, d_{12} = 2, d_{13} = 3, d_{14} = 1$,

$q_{221} = 1, d_{22} = 2, d_{23} = 2, d_{24} = 3$,

$q_{321} = 1, d_{32} = 3, d_{33} = 1, d_{34} = 1$,

$q_{421} = 1, d_{42} = 3, d_{43} = 1$.

The benefit achieved by our algorithm for Model 2 is $f_j(\bar{x}_j) - f_g(\bar{x}_g) = 720 - 651 = 69$.

Based on the results of Model 1 and Model 2 for Example 1.
we observe that the cost of the solution of Model 2 is lower than that of Model 1. The total CPU time required for finding the solution for Model 2 is 62 whereas the total CPU time required for finding the solutions for Model 1 is 62 + 47 + 62 + 62=233. For this example, Model 2 not only outperforms Model 1 but is also more efficient than Model 1.

In addition to Example 1, we also compare the cost of Model 1 and Model 2 for several cases. The duality gap for all these cases are no greater than 3% for Model 1 and Model 2. This indicates our algorithms generate acceptable approximate solutions for all these cases. The cost of Model 1 is one for each case whereas the cost of Model 2 is less than one for each case. This means the solutions of Model 2 are better than Model 1.

We also conduct several experiments to study the computational efficiency of our proposed algorithms for Model 1 and Model 2. These experiments shows the growth of CPU time with respect to $\lambda$ and $N$, respectively. This result justifies the fact that the CPU time to compute $L(\lambda)$ for a given $\lambda$ grows approximately linearly with respect to $I$ for model 1 of combinatorial reverse auction. Figure 1 indicates that the increase in the CPU time is not significant as parameter $I$ is increased. This is consistent with our expectation. The CPU time required for solving Model 1 is significantly longer than Model 2.

![Figure 1](image.png)

**Figure 1** CPU time (in millisecond) respect to $I$. A: Model 1, B: Model 2

### 6. CONCLUSION

In real world, multiple buyers may procure goods at the same time. If there are multiple buyers, group-buying may be applied to reduce the costs and benefit the buyers. The rationale of group-buying is due to demand aggregation, which benefits sellers, offering lower marketing costs and coordinated distribution channels, as well as buyers, who enjoy lower costs for product purchases. From the perspective of buyers, quantity based discounts provide a huge incentive to form coalitions and take advantage of lower prices without ordering more than their actual demand. Traditional group-buying mechanisms are usually based on a single item and uniform cost sharing. By holding a combinatorial reverse auction, it is possible to reduce the total cost to acquire the required items significantly due to complementarities between items. Therefore, combining group-buying with combinatorial reverse auctions has the potential advantage to achieve lower cost. However, combinatorial reverse auctions suffer from high computational complexity. In order to assess the advantage of combining group-buying with combinatorial reverse auctions, further study is required.

In this paper, we study two different combinatorial reverse auction models for multiple buyers. For multiple buyers that want to acquire goods by combinatorial reverse auctions, we consider two combinatorial reverse auction models: (1) Model 1: The buyers hold multiple combinatorial reverse auctions with each buyer holding a combinatorial reverse auction independently and (2) Model 2: The buyers delegate the combinatorial reverse auction to a group buyer and the group buyer holds only one combinatorial reverse auction for all the buyers. Our assessment of the advantage of combining group-buying with combinatorial reverse auctions is based on the comparative study of Model 1 and Model 2.

To compare the effectiveness of the two aforementioned combinatorial reverse auction models, we formulate two winner determination optimization problems for the two combinatorial reverse auction models and study the properties of the solutions for these two problems. By applying Lagrangian relaxation technique and subgradient method, the original optimization can be decomposed into a number of bidders’ subproblems that can be solved efficiently and iteratively. Based on the proposed subgradient based algorithms for the two problems, we compare the efficiency and performance of the two combinatorial reverse auction models. Numerical results indicate that holding a combinatorial reverse auction based on group-buying yields better performance (lower cost) than holding multiple independent combinatorial reverse auctions. Moreover, the computational efficiency of combinatorial reverse auction based on group-buying is also significantly better than multiple independent combinatorial reverse auctions. The reduction in cost due to combinatorial reverse auction based on group-buying provides appropriate index to measure the value of introducing a group buyer. Our examples show significant reduction in cost due to group-buying. This justifies the value of the group buyer and encourages the combination of group-buying mechanism with combinatorial reverse auctions.

### Acknowledgement

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### REFERENCES


INTEGRATING THE MECHANISM OF THREE-PART TARIFFS PRICING TO THE PROVISION OF INTRA-SITE SEARCH ENGINE ADVERTISING SERVICES

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ABSTRACT

Intra-site search engines (ISEs) dedicated in private electronic markets become popular with the fast-growing electronic markets. Among several research facets regarding the advertising services of ISEs, we focus on how to optimize the ISE-based advertising market mechanism by improving the pricing model. Current pricing model, Flat Fee (FF), fails to differentiate ISE advertising services among subscribers. Such inefficiency results in the loss of the subscribers, and the decline of the provider’s revenue. We design a new pricing scheme to be implemented by a two-stage contract. The proposed pricing model integrates the mechanism of three-part tariffs (3PT) to the provision of ISE advertising services. The conceived pricing model extracts more consume surplus through differentiating services among subscribers. It also develops an incentive for suppliers, and increases the stickiness of subscribers.

Keywords: search engine marketing; proprietary search engines; Three-part Tariff; Flat fee; pricing model

INTRODUCTION

In the era of information explosion, search engines play an important role in electronic commerce. For more than one decade, search engine marketing has been providing enormous business opportunities in electronic markets, and creating many successful stories, such as Google (AdWords), Yahoo! (Search Marketing), and Microsoft (adCenter). For instance, Google’s total advertising revenues were about $21 million in 2008, and grew at 8% in 2009 to hit about $23 million [1]. While public search engines (PSEs), the publicly accessible Internet information search services for users without any membership, such as Google, and Bing, have been well studied, we notice that another type of search engines is getting increasing popular but less researched. They are dedicated in proprietary electronic markets and normally require membership. The cases can be found in various forms of electronic markets, such as, eBay (Consumer-to-Consumer), Amazon (Business-to-Consumer), and Alibaba (Business-to-Business). We define this kind of search engines as intra-site search engines (ISEs).

Presently the advertising services in ISEs form a particular advertising market, denoted as Intra-site search engine advertising market (ISEAM). Users of ISE advertising need subscribe to the ISEAM services and pay the service fee. Such suppliers, called subscribers, have the privilege to use the advertising resources, mainly the clicks of clients. Commonly, ISE advertising services have been contained into a customizable premium package for suppliers.

As ISEAM is growing quickly in B2B or B2C market, relevant issues emerged in ISEAM need the effort of researchers, since many well accepted ideas in PSEs may not fit ISEs because of the differentiated features. There is a broad range of research topics in ISEAM, including search engine indexing, search result ranking from technical aspect, and keywords auction, search engine ecosystem from economic aspect. Some researchers have noticed these relevant issues. Yu et al utilized search logs of an ISE to reveal user search patterns on ISEs, which provides a validated basis for academic to conduct further research in relevant area [2]. Li at el proposed a new pricing model for ISEs advertising services [3]. Our work focuses on the pricing mechanism of advertising services on ISEAM.

Normally, the providers of electronic markets adopt FF pricing model to finance the customizable premium package, which contains ISE advertising services. FF pricing model is a fixed price for a given period of time as paid inclusion in ISEAM. FF scheme can reduce risk and administrative costs, and provide predictable revenue for providers. FF scheme, however, fails to differentiate the quality of ISEs advertising services among subscribers. Products of high-profile (strong competent) subscribers usually rank higher than those of low-profile subscribers, and hence receive more clicks from clients. As a result, those low-profile subscribers tend to quit the services package in the next period. This implies the decline of revenue of the providers. Alibaba B2B operator has met a similar situation in its member services. Alibaba B2B is the largest B2B electronic market in China. Therefore, improving the pricing mechanism is critical. The challenge for this issue is how to improve the current strategy in order to 1) extend the satisfaction of subscribers 2) increase the stickiness of subscribers 3) attract more suppliers into ISEAM to extend the revenue for providers.

This paper is intended to design a new pricing scheme to deal with the challenge. The pricing scheme is implemented by a two-stage contract through integrating the mechanism of 3PT. 3PT is defined by an access price, a usage allowance, and a surcharge for any usage in excess of the usage allowance. We introduce a twist into the 3PT to implement the two-stage contract. According to the new pricing model, a supplier paying an access price is entitled to demand to $x clicks. If consuming more than $x clicks, he needs to pay per
additional click. If consuming less than x clicks, he can gain compensation per less click. This fee is realized by adding to or deducting from his charge for the access price in the next period. The new model develops an incentive to suppliers, and increases the stickiness of subscribers in ISEAM.

LITERATURE REVIEW

There are proliferated online advertising researches outcomes. For example, Hoffman and Novak introduced a CD now case to present the trend that per-click pricing and pay for performance displace the traditional impression model in Internet advertising marketing [5]. Moon and Kwon proposed a hybrid pricing policy which integrates two most popular pricing model, cost-per-impression and cost-per-click [6]. Regarding sponsored search, Weber & Zheng exploited the way to maximize the revenue of PSE providers through designing rankings strategy of sponsored slots [8]. For another, Yang and Ghose analyzed the relationship between different sponsored search factors in 2009, and then in 2010 they extend to discuss the relationship between organic and sponsored search results [9][10]. Chatterjee and Hoffman modeled the commercial “clickstream” at an advertiser supported Web site to predict consumers interacting with advertising stimuli [11]. There are proliferated studies tackling the pricing model involving search engine advertising. For example, Sen et al compared three pricing strategies, Pay-Per-Click (PPC), Pay-Per-Purchase (PPP), and FF for paid placement on search engine services [12]. Li at el proposed a new pricing model for ISEs advertising services [3].

Presently, ISEs advertising services are integrated into a customizable premium package for suppliers. The providers commonly use FF pricing to finance the market. FF scheme is widely utilized in the previous development stage of services, such as the ticket, the telecommunication and phone. However, researchers noticed that the inefficiency of FF in financing services [13]. For example, McKnighta and Boroumand discussed the inefficiency of FF pricing for internet services, and proposed new service pricing models [14]. Therefore, researchers put forward usage-based pricing models, which are able to avoid the inefficiency of FF pricing and to extend the revenue of service providers. For instance, Sundararaja suggested that firms should transform from low fixed-fee penetration pricing in nascent information market to an optimal pricing mix including usage-based pricing options as these markets mature [15].

As noted earlier, we adopt 3PT to the new pricing scheme. 3PT have been widely used in information industries, including cellular phone plans, Internet access service, data center hosting. 3PTs are often analogized to a two-part tariff (2PT). The two-part tariff is composed of two parts, a lump-sum fee and a per-unit charge. Oi first mentioned 3PT in his classical article “Disneyland Dilemma”, and interpreted it as the price policy adopted by IBM [18], Bagh and Bhargava revealed that 3PT structure produced higher profit, and lowered managerial and decision complexity compared with 2PT [20].

In a proprietary electronic market, the websites, search engine, and so on are so-called “public goods”. Once they are supplied, every supplier, even those who did not pay to their consumption, will benefit from them. Most literature for the public goods problem is to design mechanisms to incentivize the true preference. Groves and Ledyard extended the general equilibrium model with the competitive behavioral assumption for consumers. In equilibrium, it is each individual reveals true demand of the public goods [21]. Aspremont and Gérard-Varet introduced two approaches to incomplete information. One of them is to utilize Bayesian-Nash approach to construct an efficient, budget-balancing mechanism that the beliefs of all the agents are common knowledge [22]. Crémér and Riordan extended the results of the Bayesian-Nash approach. They introduced “Stackelberg” mechanisms with truth-telling a dominant strategy for agents except for the first. According to the “Stackelberg”, the first agent plays before the others maximizing his expected utility on the assumption that others will reveal their true preferences [23].

MODEL SETTING

We focus on the scenario of two parties involved in the ISE advertising pricing scheme: ad suppliers and a service provider. There are two types of suppliers. One is service subscribers, those paying to the information services, mainly search engine advertising services, in ISEAM. The subscribers contract to a customizable premium package offered by the service provider, which consists of a series of services marketing products. Non-subscribers also are allowed to use lower prioritized search engine advertising services and other publicly available information services in the e-commerce platform operated by the service provider. Specifically, the benefit in ISE advertising services is the clicks of suppliers’ ads. By providing prioritized services to the subscribers, the service provider can resolve the free-rider problem in search engine advertising and make profit.

However, the FF pricing scheme incurs a new type of public good problem since the subscription fee is not justified by the services the subscribers receive. This can be treated as a new type of free riders problem, i.e. the fixed cost free-rider problem, in the e-commerce platform, since some better performed subscribers may overly exploit too much search engine advertising resources, leaving others much less satisfied since the advertising resource is limited.

To solve this problem, we conceive a new pricing scheme to be implemented by a two-stage contract.

Stage 1 (before service period 1):
A supplier pays a premium fee $r$ to consume $x$ amount of clicks, which changes his type to a subscriber.

Stage 2 (the end of the last service period and before the next service period):
1. If a subscriber consumed more than $x$ clicks in the previous period, a price $k$ per additional click will be
added to his charge for the services in the next period. These subscribers are denoted as high-profile suppliers.

If a subscriber consumed less than \( x \) clicks in the previous period, a compensation \( w \) per less click will be deducted from his charge for the service in the next period. These subscribers are denoted as low-profile suppliers.

Let \( p_i \) as the additional fee for subscriber \( i \) due to the additional consumption. Let \( c_i \) as the compensation for subscriber \( i \).

**Profit of Suppliers**

We consider IDEAM with a finite set of suppliers, \( N=\{1,2,3...n\} \), and one provider. Denote the competent level of supplier \( i \) as \( a_i \). The competent level generally stays constant in given periods. Denote \( s_{ij} \) as the bundle of services that supplier \( i \) consumes in period \( j \) \((j>0)\). Let \( y_{ij} \) as the cost that the supplier \( i \) pays in period \( j \) due to consuming services. Denote the revenue gained from the services package in period \( j \) as \( V_j \). The profit \( U_j \) that he gains in period \( j \) from the services package is defined as:

\[
U_j(s_{ij}, a_i) = V_j(s_{ij}, a_i) - y_{ij}(s_{ij}, a_i)
\]

(1)

The profit of subscriber \( i \) is relevant to his competent level and the services he gains.

The competent level of subscribers has three main aspects. One is the ability of subscribers to exploit search engine advertising resources. Then, it is the ability to transfer a casual click into an actual sale. Finally, it is the profitability, which depends on the performance and the quantity of products traded in one transaction. For example, there are two subscribers, C and D. For one transaction, C sells 1000 LV bags, and each package is worth $1000. D just sells one bag, and the bag is worth $100. Thus, C can gain higher profit from a deal than D. We say C has higher profitability than D. Generally, the service provider does not know the exact competent level of each subscriber.

The services subscribers consume contain search engine advertising services and other services marketing products in the customizable premium package. The search engine advertising resources subscribers exploit is influenced by their competent levels. The \( n_{ij} \) is the number of clicks that subscriber \( i \) gains, where \( n_{ij} \) as the number of impressions for all subscriber \( i \)'s ads in period \( j \). It determined by his competent level \( a_i \), i.e. \( n_{ij} = n_{ij}(a_i) \). And \( y_{ij} \) is his ads' click-through rate (CTR) in period \( j \). CTR is defined as the number of clicks divided by the number of impressions. The CTRs of slots for search results is descending. The number of clicks is the common knowledge between the provider and subscriber \( i \).

Now, we will formulize the profit of subscribers under such mechanism.

**Period 1**, where \( j=1 \).

\[
U_i(s_{1i}, a_i) = V_i(s_{1i}, a_i) - y_{1i}
\]

(1)

\( y_{ij} = r \)

Where \( U_{ij}(s_{ij}, a_i) \) is the profit and \( V_{ij}(s_{ij}, a_i) \) is the revenue if supplier \( i \) subscribes to the services package in Period 1. And \( y_{ij} \) is the cost in Period 1.

**Period \( j \)**, where \( j > 2 \).

The costs between high-profile and low-profile subscribers are different after Period 1. Thus, we formulize their profit functions separately.

For high-profile subscribers, i.e. \( n_{ij} t_{ij} > = x \)

The cost in Period \( j \) is:

\[
y_j(n_{ij} t_{ij} > x) = r + p_{ij} t_{ij} = k(n_{ij} t_{ij} - x) \quad (3)
\]

The profit of subscriber \( i \) in Period \( j \) is:

\[
U_j(s_{ij}, a_i, n_{ij} t_{ij}) = V_j(s_{ij}, a_i) - r - k(n_{ij} t_{ij} - x) \quad (4)
\]

Where \( U_j(s_{ij}, a_i, n_{ij} t_{ij}) \) is the profit if subscriber \( i \) subscribes to the services package in Period \( j \). \( y_j(n_{ij} t_{ij} > x) \) is the cost in this Period, and \( p_{ij} t_{ij} \) is the additional fee for subscriber \( i \) due to the additional consumption in Period \( j \).

For low-profile subscribers, i.e. \( n_{ij} t_{ij} < x \)

The cost is:

\[
y_j(n_{ij} t_{ij} < x) = r - c_{ij} t_{ij} = w(x - n_{ij} t_{ij}) \quad (5)
\]

The profit of subscriber \( i \) is:

\[
U_j(s_{ij}, a_i, n_{ij} t_{ij}) = V_j(s_{ij}, a_i) - r + w(x - n_{ij} t_{ij}) \quad (6)
\]

Where \( c_{ij} t_{ij} \) is the compensation for subscriber \( i \) due to less consumption in Period \( j \).

**Definition 1** In the new mechanism, commonly the subscriber \( i \) would subscribe in Period \( j \) if:

\[
U_j(s_{ij}', a_i, n_{ij} t_{ij}) > 0 \quad (7)
\]

To simplify the model, we assume the profit of non-subscriber is zero.

For high-profile subscribers:

\[
U_j(s_{ij}', a_i, n_{ij} t_{ij}) = V_j(s_{ij}', a_i) - r - k(n_{ij} t_{ij} - x) \quad (8)
\]

For low-profile subscribers:

\[
U_j(s_{ij}', a_i, n_{ij} t_{ij}) = V_j(s_{ij}', a_i) - r + w(x - n_{ij} t_{ij}) \quad (9)
\]

Where \( U_j(s_{ij}', a_i, n_{ij} t_{ij}) \) is the expected profit and \( V_j(s_{ij}', a_i) \) is the expected revenue if subscriber \( i \) subscribe to the service package in the next period. And \( s_{ij}' \) is the expected bundle of services.

The two-part contract can increase the stickiness of subscribers, especially low-profile subscribers. The expected profit in the next period can incent them to subscribe to the service package in the next period.
Profit of the Provider

Now, let us model the profit of the provider in the new pricing scheme. The profit structure of the provider contains three additional portions: the revenue from charging mechanism incomes, $P_n$, the costs for compensation for the subscribers with low clicks, $C_i$, and subscribers’ fixed fee from subscribers, $R_f$. Let $D_{ij}$, $i=1,...,N$, be the strategy space of supplier $i$ in period $j$. And $D_{ij}=1$ mean supplier $i$ subscribes to the services package in period $j$; otherwise $D_{ij}=0$. We can formulize the profit in period $j$ as follows:

$$Q_j = R_f + P_j - C_i$$  \hspace{1cm} (10)

$$R_f = \sum_{i=1}^{N} r - D_{ij}$$  \hspace{1cm} (11)

$$P_j = \sum_{i=1}^{N} p_{ij}$$  \hspace{1cm} (12)

$$C_i = \sum_{i=1}^{N} c_{i}$$  \hspace{1cm} (13)

The additional charge directly increases the profit of the provider through extracting the consumer surplus from the high-profile subscribers. The compensation increases the number of subscribers, and thus extends the fixed fee for the service provider. Properly choosing $x$, $w$, and $k$, the provider will have an increasing positive $Q_j$.

**SURCHARGE RATE VS. USAGE ALLOWANCE**

Surcharge Rate

In 3PT, a rational operator generally sets the surcharge rate close to the margin cost of his productions. In information services, however, the margin cost is almost zero. But it is not reasonable to set the surcharge rate as zero in our mechanism. Another characteristic is the demand of products. Lambrecht et al held that in 3PT the surcharge rate negatively impacts on the consumer demand [22]. In ISEAM advertising services, however, the demand for clicks does not change with the surcharge rate. This is because the click is random, and the number of clicks is determined by the clients. Therefore, we need not to consider the impact the surcharge rate exerts on the consumer demand. If the value of the surcharge rate is too high, subscribers would get negative revenue from the additional clicks. Therefore, it is reasonable that the surcharge rate should meet theorem 1.

Theorem 1 the surcharge rate does not drive the subscribers to quit when it meets the condition as follows:

$$k < E(n_{ij,t+1} - x)/ (n_{ij,t+1} - x)$$  \hspace{1cm} (14)

Denote the revenue from additional clicks is $E(n_{ij,t+1} - x)$.

Proof. The profit of high-profile subscriber $i$ is:

$$U_i(s_{ij}, a_i) = V_i(s_{ij}, a_i) - r - k(n_{ij,t+1} - x)$$  \hspace{1cm} (15)

Separate revenue gained through the service package into two parts. One is the revenue from the additional clicks. Denote this revenue as $E(n_{ij,t+1} - x)$. Another is the revenue from services excluding the additional clicks. Denote this revenue as $V_i(s_{ij}, a_i)$. The revenue can be formulized as below:

$$V_i(s_{ij}, a_i) = V_i(s_{ij}, a_i) + E(n_{ij,t+1} - x)$$  \hspace{1cm} (16)

Then,

$$U_i(s_{ij}, a_i) = V_i(s_{ij}, a_i) - r + E(n_{ij,t+1} - x) - k(n_{ij,t+1} - x)$$  \hspace{1cm} (17)

If $E(n_{ij,t+1} - x) - k(n_{ij,t+1} - x) > 0$, the subscriber $i$ can gain extra profit through additional clicks. Otherwise, high-profile subscribers would resist the new mechanism. Therefore, the surcharge rate should meet:

$$k < E(n_{ij,t+1} - x)/ (n_{ij,t+1} - x)$$  \hspace{1cm} (18)

Hence, the proof is complete.

Usage Allowance

We utilize simulation to analyze the optimal usage allowance when CTR in ISEAM meets normal distribution.

And we set surcharge rate as below:

$$k = 0.5 \cdot E(n_{ij,t+1} - x)/ (n_{ij,t+1} - x)$$  \hspace{1cm} (19)

Here, we just consider the situation of high-profile suppliers. Therefore, we do not consider the effect of the compensation on the profit of the provider in the new pricing scheme. We developed two environments, Environment1 bases on FF scheme, and Environment2 relies on the new pricing scheme. The optimal fixed fee gained in the FF pricing model is introduced into the new pricing scheme as the access price.

We control some parameters are same in two environments (Table 1). We introduce the optimal flat fee rate, $r=350$, found in the FF model into the new pricing scheme as the access price. We set usage allowance increase from 0 to 800 stepped by 20 to find the optimal value. Figure 2 presents the scatter plot for relationship between the profit of the provider and the usage allowance. The provider’ profit increases with the usage allowance, and reaches the maximum when the usage allowance is about 240. The optimal profit for the provider is 341,996. The green line is the optimal profit for the provider in FF pricing model. Figure 3 presents the relationship between the amount of the subscribers and the usage allowance. The amount of subscribers increases, and then remains stable with the increase in usage allowance. That is to say, when the usage allowance is lower than a certain threshold, it has negative impact on the decision whether the suppliers subscribe to the service package. The negative impact disappears when the usage allowance is larger than the certain threshold. Therefore, properly choosing usage allowance $x$ when CTR is normal distribution, the provider can gain more profit and the profit of the provider reaches the maximum when the usage allowance is about 240. The optimal profit for the provider is 341,996. The green line is the optimal profit for the provider in FF pricing model. Figure 3 presents the relationship between the amount of the subscribers and the usage allowance. The amount of subscribers increases, and then remains stable with the increase in usage allowance. That is to say, when the usage allowance is lower than a certain threshold, it has negative impact on the decision whether the suppliers subscribe to the service package. The negative impact disappears when the usage allowance is larger than the certain threshold. Therefore, properly choosing usage allowance $x$ when CTR is normal distribution, the provider can gain more profit and

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Parameter set</th>
</tr>
</thead>
<tbody>
<tr>
<td>Items</td>
<td>Set</td>
</tr>
<tr>
<td>Impression(n)</td>
<td>10,000</td>
</tr>
<tr>
<td>CTR</td>
<td>Normal, mean=0.03, Standard deviation =0.007</td>
</tr>
<tr>
<td>Click</td>
<td>Impression*CTR</td>
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<tr>
<td>Conversion rate</td>
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<tr>
<td>Value per transaction</td>
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<tr>
<td>Number of suppliers</td>
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<tr>
<td>The utility as a free rider</td>
<td>100</td>
</tr>
</tbody>
</table>

The 11th International DSI and the 16th APDSI Joint Meeting, Taipei, Taiwan, July 12 – 16, 2011, pp.164-170
have more subscribers.

Conversion rate is the ratio of visitors who convert casual clicks into desired transactions. The amount of impressions for all subscribers is equal to \( n \).

First we compute the optimal revenue of the provider in FF pricing model. The flat fee rate increase from 0 to 1000 stepped by 50. The number of subscribers declines with the increase in the flat fee rate. The profit of the provider increases with the increase in the flat fee rate, and then decreases with it (Figure 1).

The value of the compensation

To incent subscribers booking the services package in the next period, the provider needs to consider the value of the compensation carefully. If the compensation is too low to reach the expectation of the subscriber \( i \), the compensation would fail to incent him subscribing to the services package in the next period. If the compensation is too high, the provider has to give up. These expected utilities are obtained only when both of them agree. We use the cooperative bargaining model to address the problem [24].

Let us analyze the specificity for our game situation. In a bilateral negotiation, the symmetry should be considered. Roth argued the property of symmetry requires that the solution of the bargaining game should not distinguish between the players [25]. For our game situation, it does not meet the property of symmetry. In order to deal with this issue, we utilize the Generalized Nash Bargaining (GNB). Nagarajan and Sosic extended the cooperative bargaining into GNB through considering the risk preference [26]. They connected risk preference with the negotiation power of the players. The negotiation power means the ability of one player influences his opponent action. Nagarajan and Sosic held that a player’s bargaining power increases as his opponent becomes more risk averse. The GNB from Nagarajan and Sosic (2008) is:

\[
B(x_1, x_2, d_1, d_2; \alpha, \beta) = \arg \max (x_1-d_1)^\alpha (x_2-d_2)^\beta \quad (20)
\]

Where the constants \( \alpha \) and \( \beta \) present the negotiation powers of the two players, and \( \alpha+\beta=1 \). When an agreement is reached, players will have utilities of \( x_1 \) and \( x_2 \) respectively. And \( d_1, d_2 \) are the utilities when players fail to agree.

Commonly subscribers are risk aversion. The subscribers have lower negotiation power compared with the service provider. Utilizing GNB into the game between the provider and the low-profile subscriber \( i \), we can determine the optimal compensation \( c_{y,j} \) \((j>i)\). We assume the provider and the subscriber \( i \) are rational. The expected utilities when the players reach an agreement are:

For the provider,

\[
x_2=r-c_{y,j} \quad (21)
\]

For the subscriber,

\[
x_1=U_y(s_{y,i}, a_i) \quad (22)
\]

\[
U_y(s_{y,i}, a_i, n_{y,i}, t_{y,i})=V_y(s_{y,i}, a_i) + c_{y,j} - r \quad (23)
\]

\[
c_{y,j} = w(x_n-n_{y,j}t_{y,i}) \quad (24)
\]

We assume the subscriber \( i \) expects the revenue in the next period is same as the revenue in current period. Denote \( q \) as the real interest rate. The expected revenue in the next period as follows:

\[
V_y(s_{y,i}, a_i) = V_y(s_{y,i}, a_i)/(1+q) \quad (25)
\]

When the agreement reaches, the utility of subscriber \( i \) is:

\[
x_1=V_{y,j}(s_{y,i}, a_i)/(1+q) + c_{y,j} - r \quad (26)
\]

The disutility when the players fail to reach an agreement is zero, i.e. \( d_1=d_2=0 \). Thus, the compensation value is derived as follows:

\[
c_{y,j}=\arg \max \eta = \arg \max (V_{y,j}(s_{y,i}, a_i)/(1+q)+c_{y,j} - r)^{\beta} (r - c_{y,j})^{\beta} \quad (27)
\]

Where \( \beta \) is the relative negotiation power of the subscriber \( i \), and \( 1-\beta \) is the negotiation power of the provider. We can determine the value of compensation for the subscriber \( i \) in Theorem 2.

**Theorem 2** Compensation value determined by GNB is:

\[
c_{y,j} = r(1-\beta_i) \cdot V_{y,i}(s_{y,i}, a_i)/(1+q) \quad (28)
\]

**Proof.** We find an optimum compensation value \( c_{y,j} \) regarding to the first-order condition, and then check the value through second-order condition. First, we take a logarithm for \( \eta \) to solve the nonlinear form:

\[
\ln \eta = \beta_i \ln (V_{y,i} \cdot (s_{y,i}, a_i)/(1+q)+c_{y,j} - r) + (1-\beta_i) \ln (r - c_{y,j}) \quad (29)
\]

From the first-order condition, we have:
\[ \partial \ln \eta \partial_c \phi = \beta_i/ (V_{ij} (s_{ij}, a_i)/(1+q) + c_{ij} - r) -(1 - \beta_i)/(r - c_{ij}) = 0 \]  
(30)

\[ (r - c_{ij}) \beta_i = (1 - \beta_i) (V_{ij} (s_{ij}, a_i)/(1+q) + c_{ij}) - r \]  
(31)

\[ c_{ij} = r - (1 - \beta_i) V_{ij} (s_{ij}, a_i)/(1+q) \]  
(32)

Check the second-order derivative:

\[ \partial^2 \ln \eta \partial^2 c = - \beta_i/(V_{ij} (s_{ij}, a_i)/(1+q) + c_{ij} - r)^2 -(1 - \beta_i)/(r - c_{ij})^2 < 0 \]  
(33)

For \( \beta_i \in (0, 1) \). Hence, the proof is complete.

According to Theorem 2, the expected optimal profit for the subscriber \( i \):

\[ x_i = \beta_i V_{ij} (s_{ij}, a_i)/(1+q) \]  
(34)

The expected optimal profit for the provider regarding to the subscriber \( i \):

\[ x_2 = (1 - \beta_i) \cdot V_{ij} (s_{ij}, a_i)/(1+q) \]  
(35)

In the optimal situation, the provider bases on his relative negotiation power to extract the revenue the subscriber \( i \) gains by the services package in the next period.

According to Theorem 2, the optimal compensation rate \( w \) for subscriber \( i \) in period \( j \) meets the condition as follows:

\[ c_{ij} = w (x - n_{ij}) \]  
(36)

\[ w = c_{ij}/(x - n_{ij}) = [r - (1 - \beta_i) V_{ij} (s_{ij}, a_i)/(1+q)]/(x - n_{ij}) \]  
(37)

The provider can integrate the situation of different subscribers to determine the common compensation rate \( w \).

CONCLUSION

In this paper, we conceive a new pricing model to be implemented by a two-stage contract for ISE advertising services. The proposed pricing model integrates 3PT to the provision of ISE advertising services. This model can differentiate ISE advertising services among subscribers, and extract more consume surplus from high-profile ones. Meanwhile, it offers an incentive for suppliers, and increases the stickiness of subscribers.

There are several interesting ways to extend our current work for the future study. For instance, the new pricing scheme charges the additional usage based on the quantity. Thus, each click is treated equally in bringing the utility to subscribers. Generally, the utility of each click is different. Another, charging the additional usage based on the number of click takes the risk of click fraud, although rising sophisticated means of detection are used. Click fraud should be the issue in the near future.

REFERENCE


ONTOMETRY BASED SEARCH MECHANISM IN BILINGUAL DATABASE RESOURCE

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ABSTRACT

The focus of our research is to investigate how ontology based search system can help a novice researcher in literature search in an online academic database. In this paper, we will describe ontology construction which is based on the existing relational database system. We will demonstrate three solutions using this ontology to resolve our problems in synonym relation, short-form-term and full-term search, and bilingual retrieval.

Keywords: Semantic search, ontology, bilingual search, and synonym.

INTRODUCTION

Information and knowledge are increasingly becoming shareable and searchable resources, particularly in the current digitized world. Since 1996, the World Wide Web has become a primary source for information which offers online resources that are available 24/7. However, there is a need for a search engine to carry out query syntax for information retrieval process. Searcher has to form his own query and sometimes the query needs to be expanded. Thus searching for online resources becomes a challenging task especially for novice researchers. Studies have shown that outcome of search query is influenced by how queries are written [18, 22]. Queries conducted using advance search and Boolean techniques improves search outcomes compared to only using basic search. However using advance search and Boolean techniques require learned skills and is more complex than basic search that requires minimum skill. Basic search often uses keyword to enable users to generate a search term that best describes the query. However it is not an easy task to know what keyword to use; sometimes it is difficult to think of the correct term or word to use if the user does not have the domain knowledge. Thus it is not uncommon to find user struggles to obtain relevant search outcomes even after several attempts [16].

A number of techniques have been used to improve relevance of information retrieval. One of them is faceted search which enables categorization of documents based on more than one facet such as author, subject, document-type and so on. Another commonly used technique is Boolean search. More recently information retrieval has benefited from advancement in the Semantic Web [13]. Ontology, a set of representational primitives that include information about their meanings defined by classes, properties, relationships and constraints to model a domain of knowledge, plays a pivotal role to enable knowledge sharing and reuse in the Semantic Web [21].

This paper describes our research to develop an ontology-based search mechanism to assist university students in performing search query; in particular we focus on formulating query in a bilingual environment.

In the remainder of this paper, we organize the paper as follows. The second section presents literature review while the third section describes case background and motivation of this research. In section four, we illustrate sample outputs of three queries and we explain system development process in section five. Section six concludes the paper.

LITERATURE REVIEW

There are many languages used around the world and the needs to search information in language other than English become important [11]. There are two common systems that focus on the search language and contents; they are Cross-Lingual Information Retrieval (CLIR) and Multilingual Information Retrieval (MLIR). CLIR is a search system where the target information which listed in the search result is different from the current language in the query search box, while MLIR is to have one language in a query search box and the target information contain more than one language. Thus both the MLIR and CLIR applications require translation process of the language used [14]. Either the translation is to convert the current query language to the desired language of the retrieved documents or the translation of the documents themselves is based on the desired language the user requested for. Since the cost of translating documents is more expensive than a single translation of keyword search, many researchers of the CLIR and MLIR applications prefer to use query translation approach rather than documents translation [14].

Yilu et al. [27] identify three query translation approaches which translate queries into each target language before matching and retrieving related documents. These three approaches that can be applied into CLIR and MLIR systems are: using machine translation based (MT-based), parallel corpus, and bilingual dictionary. Finin et al. [14] stated in their paper that by using multiple MT-based systems and the question sentence, translation correctness of the keywords term can be improved. There are some other researches also trying to improve the features of CLIR [19, 25] and MLIR [14, 27]. Kim et al. [20] have used semantic category tree and collocation technique to improve precision of the CLIR system.

In online database experience, Xie [26] investigate ways to support both user control and ease of use for novice and skilled users in online information retrieval system. Lau and Goh [12] propose three methods to improve quality of the Online Public Access Catalog (OPAC) system: (i) using interactive query reformulation by recommending alternative query terms, (ii) browsing selected items in the search result list through hyperlink records, and (iii) provide content-sensitive assistance which can identify user’s searching skill.
Other studies have been conducted to address general web search problem and online database experience [6, 10, 15, 26]. Full text search has been reported as incompetent method for database information search [6]. This type of search has been unable to deal with problems of synonym, homonym, aboutness and incognito that mostly happen when dealing with the academic libraries. Chen et al. [10] report that sense of control of doing activities on the web generally is influenced by how the web environment is such as users finding it easy to use the web search if they are familiar with the environment and have the sense of being able to control the web environment. For example, users go for deep search when their first search leads them to more information and they know how to go to next step. Xie [26] describes problems of online database and web search engines when categories of presentation are not well structured and irrelevant results are obtained. In addition, Griffiths and Brophy [15] explain how successful information search often relied on having some check point item to support results.

Beall [6] identifies synonym relation problem. For example, the words ‘mum’, ‘mother’ and ‘mummy’ all refer to the same meaning of ‘mother’. It is important to consider a range of words when using open keywords. Variant spelling is also another problem; for instance, spelling variant between American and British words; color/colour. This kind of problem can be overcome by adding both words when querying. However this approach can become complex when more than one words are involved. Short form term has made it easier to refer as in business name, centre names, familiar terms and others such as WWW for World Wide Web, USA for United States of America. As the short form term is often represented by the first letters in the sentence names, the possibilities of having the same short form term cannot be discounted. For example, COM may be a shortened form for “communication” or ”commercial” or even can be a short form term for “Center of Momentum”.

Another problem of full text search in information retrieval area involves multi language. Previous traditional database systems are unable to process any query that used a keyword term in another language and request to retrieve the document in a different language. For instance, network in English language is referred as “rangkaian” in the Malay language. Common databases are unable to search documents which are written in the Malay language if the keyword used is in English language since the system used keyword matched approach to search for related results. In addition, the search system is also unable to deal with homonym problem where the word has more than one meaning. For examples, the word “sort” can refer to categories or a kind of things or it may refer to “putting elements in a certain order” as in computer science and mathematics. The various types of problems described here are compounded by machines and computers unable to understand meaning of words as that understood by human.

Relational database is commonly used to store all database records. Records are kept in the database to enable search by the query engine. However, common problems encountered in the full text search results include its lack of precision, relevance and sorting of returned documents result in most related documents cannot be organized into specific published dates, authors name, titles or even subjects [6]. Very often the query engine can retrieve a list of search results but it still requires human interpretation when links/urls are imprecise, loosely classified and lack of machine interpretation capabilities. Human judgment is required in determining which documents are relevant and which are not. Ontology provides a means in which semantic search can be implemented. Ontology enables contextual relationships in the database to be defined and data is given a well-defined meaning that is consistent across context. Furthermore, with the contextual relationships defined in the ontology, more information can be provided to describe ontology domain.

Semantic search is yet to be extensively replacing web-based Boolean search. The number of information that is machines-understandable is not high enough to be used through the semantic search engine for general purposes. However, there is an increasing number of semantic web projects developed using semantic approaches and technologies such as Semantic web portal (Swoogle, Hakia, GoPubMed, etc), corporate semantic web such as Corese (http://www.sop.inria.fr/acacia/soft/corese/) and social semantic web such as SIOC (http://sioc-project.org/) and Twine (http://www.evr.com/). In fact most of the industry groups and individuals who are pertaining to the dynamic search environment are considering building ontology-based database records.

As explained, ontology provides a means in which semantic search can be implemented. Ontology database can improve search result accuracy using structured categorization of classes and subclasses which enable contextual relationships to be defined and data be given a well-defined meaning consistent across context. Thus semantic search that is capable of understanding the search intent can overcome failing of traditional web-based full text search.

Currently implementation of ontology is found in a variety of development tools and methodologies. Ontology can be built from scratch or reused from existing ontologies. The preference generally lies with the developer as well as how the ontologies are applied. Casely-Hayford [9] has reviewed extensively on methodologies, languages and tools for building ontologies. To facilitate reuse and sharing of ontology, developers can refer to existing ontologies in libraries such as NCBO BioPortal Ontology [2], Protégé Ontology Library [4], Swoogle [3] and DAML Ontologies [1].

There are several works that address the ontology construction approach. Some of the approaches include (i) starting ontology development from scratch, (ii) transforming or migrating database schema from relational database into existing ontology using a mapping process, or (iii) joining or merging two different existing ontologies together [5, 17]. Stojanovic et al. [7] propose an approach based on semi-automatic generation of ontology from a relational database model using a F-logic inference engine. This ontology generation approach first forms the relational database model into equivalent class structure in the ontology, which then maps the content of the database into ontology. User intervention is required to choose the most
suitable reverse engineering techniques of mapping relational databases into ontology [8, 23].

CASE BACKGROUND AND MOTIVATION

The focus of our research is to investigate how to help a novice researcher in conducting literature search as a first step of choosing a research project or research thesis. In the university under our investigation, students are required to complete a one semester research project to complete their degree requirement. However, students who embark on research project for the first time often find identifying a viable research topic to be a daunting process. Choosing a research topic for thesis and dissertation is a complex process. The students not only need to have some interests in the topic area, they also need to choose a topic area that will make contribution to the area of research. It is not uncommon for students to seek advice from academic staff from the department they enrolled in; they will also search existing literature to determine how much information is already available on the topic. Usually students also search previous dissertations or thesis available in the library to identify potential research topic. This approach not only functions as a good starting point, it also enables student to develop an initial focus on the research topic that s/he wishes to embark on.

Very often these students are novice inexperienced researchers who may not be skilful in searching for information. Although students have undergone at least three years of undergraduate study before embarking on the research programme and have acquired some degrees of literature search skills or using library services, very often their literature search experience is limited. For example students often are given a list of bibliographies or reference lists in the subject area by their lecturers, which provide a good starting point when literature search is conducted. This may not be the case when students need to search for a thesis or dissertation topic that is of interest to them as well as a doable research topic that can be completed within the specific time frame of their degree. Thus a search and retrieval system that can help students in this initial phase of identifying research topic is desired.

SYSTEMS DEVELOPMENT

The ontology is considered as our main database resources for the proposed online thesis searching. We decide to develop an ontology-based search system based on the existing relational database. We aim to develop an ontology that can overcome problems encountered in keyword search such as synonym, short form term and bilingual query.

Figure 1 shows a partial snapshot of ontology used in this project. The ontology is designed based on the scope of keywords used in the Education Faculty as well as by conducting examination of keywords used in past thesis database. We have made teaching, learning and level as the three main classes. This is because courses and research areas in the Faculty deal with teaching and learning and preparing students for future teaching career at five levels of education (primary, secondary, matriculation, diploma and university) in the country. Research on teaching and learning is conducted based on the level of education. The organization of ontology in this way enables us to move away from the department-course hierarchy. In the teaching and learning classes we have included eight sub-classes, which are approach, factor, learner, performance skill, strategy, subject and tool. The determination of these eight sub-classes is based on common themes in which research thesis have been conducted in the past.

![Figure 1: A partial snapshot of hierarchy of thesis ontology.](image)

The advantages of classifying ontology this way is to enable students to have a unified structure when searching the thesis database. When a student conduct a query, what it has in his/her mind is “I am interested in investigating research issues on teaching of mathematics for secondary school children because that is what I am trained for and I like to investigate strategies or approach of teaching mathematics using computers”. This query can be illustrated in the following hierarchical form:

**Teaching: Approach**

This way the students are not searching the database based on keywords that were included in the index of the system. On the other hand, we are using our own formulation of relationship in determining the flow on how to search for information. We call this dynamic search which can offer flexibility how query is made.

Consider an example when the user is searching for past research topics that are related to “teachers’ perceptions of delivering lessons using computer assisted learning”. Using the ontology as described in Figure 1, we can structure the search as follows:

**Teaching: Approach: Computer**

Consider another example where the user wants to search “compare learning styles second year education students
compare with the teaching styles of their lecturer”. Using the above ontology the search can be formulated as:

**Teaching: Approach: Style**

**Learning: Approach: Style**

The next step after the ontology is created is to consider bringing in all records into appropriate class-subclasses properties. The process of dumping data from MySQL into Protégé is carried out using Protégé Plug-in called “Datamaster” [24]. The importing process is done through its user interface where a connection to relational database is established. We have an option to import either the entire database or only some of the tables. In our project, we used the option to bring the entire database.

![Figure 2: System framework](image)

Figure 2 shows the system framework of the proposed system, which includes a process of mapping current database schema into ontology. The ontology database is converted into RDF data and parsed into XML model. Once the query has been submitted the result is returned in a list of URL links that contain the thesis. After the mapping process is completed, we set the relationship of the class-subclasses and set the synonym relation, create common short form terms for individuals and managed the English-Malay related keywords.

As described in the previous section, it is desired that the system is able to handle bilingual query. This can be achieved as the system uses synonym to meet this requirement. Users do not have to conduct separate searches using keywords in different languages. For example, the first query is to use the phrase “motivation of learning” and then a second query is issued using “motivasi pembelajaran”, which means motivation of learning in Malay (Bahasa Malaysia) if keyword search is used. Instead synonym can be used to identify corresponding words in either language. Similarly synonym can be used to define acronym such as T&L for teaching and learning, PBL for problem-based learning, CAI for computer-aided instruction and so on.

**SYSTEMS OUTPUT**

We use the following three scenarios to show the difference between keyword search and ontology search.

**Scenario 1 - Information retrieval based on shortened forms of terms (UHB1412-English for Academic Communication)**

In this scenario the student likes to know any research projects that are related to the subject UHB1412 “English for Academic Communication”. The query result should retrieve title that has the keyword either ‘UHB1412’ or subject name “English for Academic Communication”. Figure 3 shows the output result.

![Figure 3: Query 1 - shortened forms of terms](image)

We can see two records have been retrieved from the query syntax in Figure 3 as follow:

**The01012**

“A Survey on the Language Learning Strategies Used by the UHB1412 Students”

**The01013**

“A Survey on the Language Learning Strategies Used by the Students of English for Academic Communication”

These two records were retrieved from the domain ontology as we give meaning to both individuals/instances which the reasoner can understand the relationship between them. Figure 4 shows how the relationship is represented between these two words which we have defined using the synonyms relation of ‘SameAs’.

![Figure 4: Relationship of “SameAs” Individuals](image)

**Scenario 2 - Information retrieval based on different language or dialects (English-Malay Language)**

In this university we have two cohorts of students, domestic local students and international students.
students are fluent in the local language of Malay and the international students use English as the medium of instruction and communication.

Figure 5: Query 2 - different language or dialects

In this scenario, the student wishes to identify all theses, written in Malay and English, in the research topic of ‘teaching’. For local students they will probably choose to use the keyword ‘pengajaran’, whereas for the international students they will use the keyword ‘teaching’. Thus the query that can handle both languages is desired. Figure 5 shows the result in which three records are returned as follows.

“Penggunaan Komputer Dan Internet Dalam Pengajaran Dan Pembelajaran Di Kalangan Guru Sekolah Menengah Di Daerah Pasir Mas, Kelantan”

“Pendekatan Pengajaran Yang Digunakan Oleh Guru Sekolah Menengah Di Daerah Johor Bahru Dalam Pengajaran Dan Pembelajaran Matematik”

“A Comparative Study On The Learning Styles Of Second Year Education (living Skills) Students And The Teaching Styles Of Their Lecturer”

Scenario 3 - Information retrieval based on synonym relation (Intelligent: AI, Smart)

In this scenario, the student likes to conduct a project development on some form of smart application and would like to know whether any research has been conducted in this area. Thus the student will think of possible keyword such as ‘smart application’. However, the keyword of ‘smart’ is not the only word that can describe smart application. There are some other words that are capable to describe smart application such as AI (artificial intelligence) or intelligent. In our project we use synonym relation to give more meaning to data.

Figure 6: Query 3 – synonym keyword search

Figure 6 shows the results that include all the synonym words that have been refer to the keyword term of ‘Intelligent’ which list as follow:


Sistem Pencegahan Kecurian Dan Rompakan Kenderaan ‘smart System’.

Intelligent software system for CD-ROM project archives.

CONCLUSION AND FUTURE RESEARCH

Our research is based on the concept of ontology information retrieval. In our preliminary work, we have utilized existing database system to map into new ontology schema. Synonym-relation word, short-form term and bilingual query term are included in the domain ontology. Outcomes have shown that search can be performed to meet user queries. In the future, we are going to work on developing web user interface to allow an online archive of the database records. We will consider generating a dynamic drop-down keyword search to help novice researchers in their search process. In addition, we will conduct our investigation by examining various structure of domain ontology in the search process.

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v. Library.


Critical Success Factors in Ubiquitous City Implementation: A Capability Perspective of IT Service Company

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ABSTRACT

In recent years, a city becomes urbanization, and several urban problems are being occurred. The demand of efficiency for the urban function is increasing, and the ubiquitous IT receives attention for the solution of that. IT companies are leading this change. Thus, IT companies need several capabilities to solve these challenges. This paper aims to identify Critical Success Factors (CSFs) of u-City implementation based on expert interview research. In addition, the expert survey research is conducted about drawing capabilities to achieve each of the CSFs. This study will provide the guidance to draw the capabilities of IT company in u-City industry.

Key words: Critical Success Factors, u-City implementation, IT Service Company, Capability

Chapter 1. Introduction

1.1 Background

Ubiquitous City (u-City), considered a promising solution for various urban problems using Information and Communication Technologies (ICT), is expected not only to realize efficient urban functions but also to be more economical and to improve convenience and smart living quality of the residents.

On the government level, related laws and regulations are established and revised, new technology and human resource development and support will help fast-growing IT services based urbanization, and u-City industry is being developed to enhance nation’s competitive force. In Aug. in 2009, 52 areas in 36 local governments were under development or planning of u-City.

Ubiquitous City (u-City) is known as an integrated business with various fields involved and the related officials should form a common ground for the business; for a successful u-City business, many of IT service companies should gain internal competencies on u-City fields as well as on IT industry while continuing innovation effort with new perspectives.

1.2 Purposes of the study

To draw capabilities for successful u-City implementation from an IT service company, this paper was conducted on two levels:

First, success factors from IT service company perspective were drawn to identify competencies necessary for u-City implementation.

Second, essential competencies for IT business were drawn for establishing a foundation for successful and competitive u-City business

Chapter 2. Literature Study

2.1 Understanding the concept of u-City

2.1.1 Definition and characteristics of u-City

Prior to definition of u-City, ubiquitous concept should be discussed. According to u-City development and support laws, u-City provides ubiquitous services anytime, anywhere by realizing u-City technologies within a city space to enhance living qualities and competitive force of the city. Im (2005) defines u-City as “a next generation information city that converges cutting-edge IT infrastructure and ubiquitous information services in a city to realize innovative urban infrastructure” [12]. NIA defines u-City as “a new city concept that offers innovation of the existing information infrastructure, better IT services, convenience and safety for more efficient city function and management.” Choi et al.(2005) define it as “a ubiquitous computing city connected to electronic spaces of computer-installed environments, objects, etc. for information sharing and communication” [4]. MLTM defines it as “a city in which cutting-edge IT infrastructure is established based on a sustainable urban environment for efficient environment control and initiative resident involvement and cooperation.”

Jung (2008) proposed future visions of a city and ubiquitous technologies within an urban space that provides u-IT-based cutting-edge services in real time and optimizes convergence and integration of the city functions to develop a next generation information city in the 21st century [18].

For the characteristics of u-City, first, u-City is an IT-applied ubiquitous space. This means providing information anytime, anywhere in real time through IT technologies and IT-based services.

Second, it brings innovative urban living environment. Optimization of urban function convergence and integration leads to innovation of urban living environment.

Third, the goal of u-City is to improve living quality of the citizens. The ultimate goal of u-City is for better living convenience and quality.

Lastly, u-City is a city that grows with residents’ involvement and cooperation. The subject is the residents and the city grows by their involvement and cooperation.

2.1.2 u-City development

U-City industry in Korea is being currently driven by MOPAS, MLTM and other central ministries and local authorities.

MOPAS focuses on extending services that help the residents directly and announced “u-Life21” as the basic plan for local information system. MLTM is planning to...
realize the world first u-City of ubiquitous and intelligent space and developing u-City standard models.

For developments in local governments, Seoul proposed u-Seoul vision for ubiquitous-based international business city and established visions in 6 major local areas. Incheon seeks Digital Well-Being and business-oriented city through its u-City. Busan focuses on promoting Busan u-City and securing its global competitive force by pre-occupying the world first u-City. Gwangju, under its goal of building a ubiquitous cultural capital, established its u-City development plan. Daejeon established its u-City development plan as well, under the vision of global hub of science and technology.

2.2 u-City strategies for IT service companies

◆ Samsung SDS

Samsung SDS established the infrastructure for ubiquitous environment as well as ultra high speed telecommunication network and an integrated control center; the company differentiated the u-services into home, complex and social overhead facility services for efficient service delivery.

◆ KT

KT set the future u-city image as a city of better living and better business. For a city of better living, the services were divided into the categories of convenience, health, safety and pleasant environment. For a city of better business, u-City models were established for industrial value chains, more cooperation, industry vitalization and support and more domestic and international exchange.

◆ LG CNS

LG CNS established u-City visions for the future city in the 21st century, of integrated business, new government and intellectual living. City functions were divided into the public and residential sector.

◆ SK C&C

SK C&C established various u-City business models including u-City model for home network and telematics services; digital home business is being trial-run as a u-City-related business.

2.3 Success factors of u-City implementation

Current studies on u-City success factors have focused on the government level, services and infrastructures and management. U-city success factors, infrastructures, u-services, u-City management and u-service-based e-government-related studies were reviewed for identifying success factors.

Jeon (2006) proposed re-investment in infrastructures and technology development by establishing urban infrastructures and new services to utilize advanced technologies and various contents in ubiquitous society for successful u-City development. Advanced networks, ubiquitous sensors and network core technology-applied ubiquitous environment are needed for urban infrastructures and differentiated public services and various additional services for u-City are needed for adopting new services to create new demands. Jeon (2006) also suggested the necessity of establishing flexible urban planning system that responds to growing additional service market and technology development through proposing u-City concept, building u-City, categorizing each business subject and standard integration of applied technologies [35].

Kim, et al. (2007) proposed 14 items in 4 areas of technology, business, profit and policy through u-Business success factors in a study on business validity and evaluation index for u-City Business Models [29]. Jeong(2007) proposed 6 success factors of ‘u-Service standardization’, ‘u-IT technology development’, ‘infrastructure establishment’, ‘setting of laws and institutions’, ‘information protection enhancement’ and ‘international cooperation’[3]. Kang (2009) proposed factors of improved laws and institutions; u-City model standardization; technology standardization; technology development; information integration and management; clear identification on the business subject; securing financial support; and user demand analysis [34].

Baek et al. (2008) proposed 7 critical success factors including successful business model development; differentiated and enhanced industry strategies; better environment for investment; building infrastructures; securing self-sufficiency; and maximizing affiliation by using Delphi method [32]. Choi (2007) proposed success factors of establishing infrastructures; creating environment for investment; developing business models; maximizing industry affiliations; differentiation of industry developments; strategy enhancement; and policy support [27].

Yoon(2008) proposed success factors of specific and comprehensive plans; establishing integrated development system; government support; improved laws and institutions; standardization, integration, technologies and R&D support; user-oriented business; creating demand and business environment improvement; profit model development; reducing social impediments; securing budgets, and human resources development [28]. Shin(2007) proposed success factors of technology standardization, technology development, securing human resources; information protection; laws and institutions; creating base of vitalization; and establishing development system among the operating bodies [25].

Jang (2010) proposed success factors of establishing visions; sharing beneficiaries’ service experiences; improved laws and institutions; government support; role division by business body; integrated management of service models; tasks, process, development methodologies; technology and service standardization; and growing communication experts [33]. NIA(2008) proposed improving laws and institutions; standard service models; cooperation among the departments; u-City business operation methodologies; and securing adopting original technologies [21]. Kim et al. (2009) proposed success factors of system/network qualities; information qualities; IT service qualities; usability; and trust on the service providers [17]. Hur et al. (2008) proposed success factors of technology levels; business organization characteristics; customer characteristics; and external environment [31]. Oh et al. (2006) proposed success factors of combined efficiency; well-being care; and respect for mankind [22].

Kim et al. (2009) proposed success factors of clarifying the roles of business bodies; improved laws and institutions; developing profit models; core technology development; and

Based on above literatures, table 2-2 summarized success factors for u-City implementation, based on 20 studies in Korea regarding u-City infrastructures, u-Service, u-City management, and u-Service-based e-government.

2.4 Core competencies of a business

2.4.1 Core competency concept

The theory of core competence advocated a firm with a combination of technologies and knowledge owned by the organizational members; intangible asset is more emphasized than material asset, the members learn how to control various production technologies and how to coordinate the technology flow; it is an unique capability for increasing customer values and more efficient value delivery [5]. Core competency is also a combination of knowledge, technologies and attitudes necessary for core tasks and accomplishments that realize organizational visions and strategies. It is a measurable behavior that draws successful results based on knowledge, skills, attitudes and interactions of organizational values consistently observed in the members of successful accomplishments [5], [6].

Core competency has various characteristics as listed below:

First, it is changeable [13]. As situations and environments of a company change, core competencies are decided or change accordingly. Second, it is difficult to measure and detect. Collecting information and selecting measuring tools are difficult and systematic framework is required [8]. Third, it shows Inimitability. It also shows Tacitness, Complexity, Speciality and Causal Ambiguity. Fourth, it shows Immobility and Non- Substitutability. Core competency cannot easily move from one company to the next, which makes consistent economic profit available [9]. Fifth, it shows Invisibility. Invisibility makes competitions unable to imitate, which promotes the values even more.

Sixth, it shows Durability, which increases when a competency is shared and applied. It also shows exclusive appropriability (Gilgous & Parveen, 2001 [9]).

2.4.2 Core competency structure

Core competencies on the top level, Resource, Capabilities and Competencies comprise of a 4-level structure and [Figure 2-1] shows the diagram. The first level, Resource, varies in companies; Capabilities indicate abilities of using resources. Capabilities include a series of business activities that manage interactions between business processes and resources (Javidan, 1998 [16]). Capabilities also play important roles that are crucial to company survival, yet cannot offer upper hand within the same industry. The aspect separates Capabilities from core competencies (Prahallad, 1993 [23]). When various capabilities act together through integration of various functions, it realizes Competencies, placed in the level above. Lastly, the last level, Core Competencies, is drawn from interactions among capabilities. Therefore it can be said that Core competencies are a collection of various capabilities [15]. In this study, ‘Competencies’ or ‘Capabilities’ will be used to indicate company capabilities, due to the embryonic stage of u-City industry.

![Figure 2-1] Core Competency Structure

2.4.3 Company capabilities

Studies on company capabilities have been studied with various perspectives and this study conducted literature study on characteristics of u-City, IT-related ‘innovation’, ‘services’, ‘organisations’ and other IT-related materials. In their company capabilities study related to innovation, Hult et al. (2002) proposed market-oriented, learning-oriented and enterpriser-oriented capabilities for company innovation in their study on innovation associated with business showings [11]. Yam, in his study on technology innovation capabilities of Chinese companies, proposed learning, R&D, resource allocation, manufacturing, marketing, organization and strategic planning capabilities [27]. There are studies focusing on market, technology, production and innovation; in some of the studies, the categories are market-oriented, R&D-oriented and production-oriented [8]. A study done in Korea suggested the effect of innovation factors and capabilities on manufacturing businesses and proposed the importance of R&D, production and learning.[14]. In a study on service-related capabilities [20], company strategies, customer-oriented marketing, technologies and services, image marketing, stability and financial capabilities were proposed for promoting competitive force of a company.

Traditional capabilities-financial, strategic and technological capabilities-and organizational capabilities-value sharing, management, changing ability and leadership-are considered important for company’s competitive force [7]. Piao (2005) proposed management system, management strategies, marketing strategies, company culture, information system, resource, process, quality, market competitiveness, business accomplishment, new product development, company image, market information, design, R&D, investment, A/S, legal restriction, product prices, relationships, introduction to the market, know-how, constant trust and support, incentive, organization culture and human resources as capabilities of IT companies.

Regarding capabilities of IT companies, Kang (2010) proposed customer understanding on the business, customer-friendly system management, project experiences and practice, customer-oriented IT consulting service system, human resources, customer and field-oriented service mind, customer leadership, financial stability and sales capabilities [30]. Song (2009) proposed general management, new
technologies, specialized tasks, sales and individual personnel as categories of IT business capabilities [26].

Chapter 3. Research Methodology

In this paper, expert interviews were conducted on 13 IT service companies that run u-City business to verify CSFs and collect additional CSF as shown in [Figure 3-1].

Based on the interviews, literature study was conducted to draw company capabilities necessary for achieving CSFs and deriving capability-related data. Studies on national/international innovation, services, organization and IT-related issues were used to draw capabilities or competencies. Capabilities drawn from the studies were presented as examples and company capability data was established through surveys for identifying company capabilities necessary for achieving CSFs; the surveys were conducted on 30 experts who were interviewed.

Collected data was processed through Content Analysis and literature study and interview results were organized as CSFs; CSF literature study and interviews were processed with Frequency Analysis to define the overall CSFs. Lastly, CSFs and literature study and interview results were organized as Technological and technical factors.

Collected data was processed through Content Analysis and literature study and interview results were organized as CSFs; CSF literature study and interviews were processed with Frequency Analysis to define the overall CSFs. Lastly, company capability data collected from surveys was processed with Frequency Analysis to draw major company capabilities according to success factors and categories. Chi-square Test was used to verify the association between u-City critical success factors and company capabilities.

[Figure 3-1] Study Methods Process

3.1 Data collection

3.1.1 Literature study on success factors of u-City implementation

For closed study on the interviews, success factors commonly suggested from the existing studies were categorized and organized by ubiquitous e-government service study model [10] based on BSC(Balanced Scorecard) perspective.

<table>
<thead>
<tr>
<th>No.</th>
<th>Success factor</th>
<th>Definition</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Establishing u-City concept and the models</td>
<td>Establishing u-City concept and models based on user benefits and economic effect</td>
<td>Environmental/institutional factors</td>
</tr>
<tr>
<td>2</td>
<td>Clear division according to business bodies</td>
<td>Clear role and range division according to business bodies and steps related to various interests</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Establishing urban planning system</td>
<td>Establishing integrated planning system through city planning process models</td>
<td></td>
</tr>
</tbody>
</table>

[Table3-1] CSFs for u-City implementation

3.1.2 Literature study on company capabilities

Among literatures on national/international innovation, services, organizations and IT, ones referring capabilities or competencies were used to draw, examine and organize capabilities. Ulrich (2008)’s model was used to analyze company capabilities; traditional financial, strategic, technological and organizational capabilities were added to the model as shown below [19].
Kim Chul Nyuon, Lee Jung Hoon & Kim Eun Young

<table>
<thead>
<tr>
<th>No.</th>
<th>Success factor</th>
<th>Description</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Financial stability</td>
<td>Credibility, scale and financial stability</td>
<td>Economic/financial capability</td>
</tr>
<tr>
<td>2</td>
<td>Investment capability</td>
<td>Business support and investment capability</td>
<td>Economic/financial capability</td>
</tr>
<tr>
<td>3</td>
<td>Profit</td>
<td>Profit-generating ability through company’s financial capability</td>
<td>Economic/financial capability</td>
</tr>
<tr>
<td>4</td>
<td>Understanding the markets and customers</td>
<td>Delivering company values to customers; customer-oriented management and management skill</td>
<td>Strategic/marketing capability</td>
</tr>
<tr>
<td>5</td>
<td>Customer leadership</td>
<td>Sales, sales management, sales know-how, sales sense, and related capabilities</td>
<td>Strategic/marketing capability</td>
</tr>
<tr>
<td>6</td>
<td>Building relationships</td>
<td>Establishing and managing network of stakeholders</td>
<td>Strategic/marketing capability</td>
</tr>
<tr>
<td>7</td>
<td>Strategic planning</td>
<td>Setting goals, strategies; operating plans</td>
<td>Strategic/marketing capability</td>
</tr>
<tr>
<td>8</td>
<td>Negotiation skill</td>
<td>Negotiation and contract skills</td>
<td>Strategic/marketing capability</td>
</tr>
<tr>
<td>9</td>
<td>Developing and operating new businesses</td>
<td>Discovering new businesses; business operating skills</td>
<td>Strategic/marketing capability</td>
</tr>
<tr>
<td>10</td>
<td>Image marketing</td>
<td>Establishing company/brand image (promotion and advertising)</td>
<td>Strategic/marketing capability</td>
</tr>
<tr>
<td>11</td>
<td>Developing business models</td>
<td>Developing and establishing business models</td>
<td>Strategic/marketing capability</td>
</tr>
<tr>
<td>12</td>
<td>Collecting and using information</td>
<td>Information analysis, market research, trend analysis and other capabilities to collect and use information</td>
<td>Strategic/marketing capability</td>
</tr>
<tr>
<td>13</td>
<td>Competitive prices</td>
<td>Competitive product/service rates</td>
<td>Strategic/marketing capability</td>
</tr>
<tr>
<td>14</td>
<td>Customer services and follow-up</td>
<td>Follow-up for products and services, customer support system</td>
<td>Strategic/marketing capability</td>
</tr>
<tr>
<td>15</td>
<td>Consulting capability</td>
<td>Consulting capabilities for customers</td>
<td>Strategic/marketing capability</td>
</tr>
<tr>
<td>16</td>
<td>Service productivity</td>
<td>Service productivity (Service efficiency against cost)</td>
<td>Strategic/marketing capability</td>
</tr>
<tr>
<td>17</td>
<td>Technology innovation</td>
<td>New technology development and technology innovation</td>
<td>Technological capability</td>
</tr>
<tr>
<td>18</td>
<td>Acquiring and internalizing new technologies</td>
<td>Acquiring, applying and managing new technologies and knowledge</td>
<td>Technological capability</td>
</tr>
<tr>
<td>19</td>
<td>R&amp;D</td>
<td>Establishing technology development competency and the development process</td>
<td>Technological capability</td>
</tr>
<tr>
<td>20</td>
<td>Developing new products and services</td>
<td>Developing competency for new products and services</td>
<td>Technological capability</td>
</tr>
<tr>
<td>21</td>
<td>System development and application</td>
<td>Development/application competency for customer-oriented systems</td>
<td>Technological capability</td>
</tr>
<tr>
<td>22</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[Table3-2] Organizational capabilities

3.1.3 Interviews on CSFs and surveys on company capabilities

Interviews on u-City CSFs were initially conducted on IT experts in u-City business by dividing them into groups of 2-5 people. First, the objectives of the interviews were explained and the interviewees answered questions on the importance of each factor based on the Likert scale of 7 against CSFs.

Surveys on company competencies were conducted on the experts who participated in the interviews on CSFs for u-City implementation

3.2 Method of Data analysis

Analysis on the collected data was completed according to the nature of the data. To quantify qualitative data, Content Analysis was used; data drawn by the Likert scale were analyzed by the mean and variation. Frequency Analysis was applied to analyze the importance of the quantitative data. Correlation Analysis on literature study and the interviews was done by Spearman rank Correlation. To examine the significance of the correlation between the CSFs and company competencies, cross analysis (Pearson Chi-Square Test) was applied.

Content analysis method is to draw valid deductions from the texts by a series of procedures [23]. In this study, additional u-City success factors drawn from the interviews were analyzed and examined whether the factors were included in the ones from literature analysis or those were separate ones. U-City CSFs that reflect the Content Analysis
results are as follows. Frequency Analysis is to create Frequency Table by category and variable and proper graph (e.g. bar chart, pie chart). It shows frequency of the variables and relative ratio [2]. Major factors drawn from literature study were used to measure the frequency. It was also used to analyze company capabilities.

Chapter 4. Data Analysis

4.1 Standard data analysis

20 studies on u-City success factors were selected for literature study to draw CSFs for u-City business success factor analysis. Interviews on u-City success factors were conducted on 30 experts from 13 IT companies from Nov. 17~27, 2010. The companies to which the interviewees belong were limited only to IT companies. Therefore the all subject companies were IT companies. Interviewees included u-City consultants (40%) and u-City project managers/leaders (40%). The length of employment in the field, 72% of experts had worked in the field for 2~8 years and about half of the interviewees had 2~5-year experience in the field since u-City has been developed in Korea for less than 10 years.

![Figure 4-1] Demographic data

4.2 CSFs analysis

This section proposes u-City CSFs drawn from literature study and interviews and organizes “CSFs” after comparison and analysis from two different perspectives.

Expert review to verify validity of the results drawn from literature study and the interviews was done by 2 experts who were interviewed. Major points of the review include: first, securing mutual exclusiveness of CSFs; and second, evaluation on CSFs based on literature analysis and the interviews to draw CSFs for company core-competencies.

Major review results are as follows. U-City success factors proposed by the experts in the interviews reflected the definitions of 17 success factors which are overlapped with 17 success factors drawn from literature study. ‘Leadership’ showed low importance both in literature study and interviews, therefore was excluded from the list of success factors; 16 factors, 1 excluded from the list of 17, were drawn as u-City CSFs.

Success factors were drawn from 20 studies on u-City success factors and the frequency in the studies was examined and prioritized accordingly. Closed interviews were conducted to measure the importance of each success factor based on the 7-point Likert scale. Each success factor was measured for its importance through mean value comparison.

<table>
<thead>
<tr>
<th>No.</th>
<th>Critical Success Factors</th>
<th>Literature Study Importance</th>
<th>Interview Importance</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Establishing and supporting operating cost</td>
<td>7</td>
<td>1</td>
<td>Economic/financial capability</td>
</tr>
<tr>
<td>2</td>
<td>Supporting policies</td>
<td>10</td>
<td>1</td>
<td>Strategic/market ing capability</td>
</tr>
<tr>
<td>3</td>
<td>Developing profit-creating new services</td>
<td>5</td>
<td>3</td>
<td>Economic/financial capability</td>
</tr>
<tr>
<td>4</td>
<td>Developing products, services and technologies</td>
<td>3</td>
<td>4</td>
<td>Technological capability</td>
</tr>
<tr>
<td>5</td>
<td>Creating an environment for investment; expanding markets</td>
<td>3</td>
<td>5</td>
<td>Economic/financial capability</td>
</tr>
<tr>
<td>6</td>
<td>Establishing laws/institutions</td>
<td>1</td>
<td>5</td>
<td>Strategic/market ing capability</td>
</tr>
<tr>
<td>7</td>
<td>Technology and service standards</td>
<td>1</td>
<td>7</td>
<td>Technological capability</td>
</tr>
<tr>
<td>8</td>
<td>Clear division according to business bodies</td>
<td>7</td>
<td>8</td>
<td>Strategic/market ing capability</td>
</tr>
<tr>
<td>9</td>
<td>u-City network infrastructure establishment and advancement</td>
<td>6</td>
<td>8</td>
<td>Technological capability</td>
</tr>
<tr>
<td>10</td>
<td>Establishing urban planning system</td>
<td>15</td>
<td>10</td>
<td>Strategic/market ing capability</td>
</tr>
<tr>
<td>11</td>
<td>Project management</td>
<td>16</td>
<td>11</td>
<td>Organizational capability</td>
</tr>
<tr>
<td>12</td>
<td>Securing and growing experts</td>
<td>12</td>
<td>12</td>
<td>Organizational capability</td>
</tr>
<tr>
<td>13</td>
<td>Establishing u-City concept and the models</td>
<td>12</td>
<td>13</td>
<td>Strategic/market ing capability</td>
</tr>
<tr>
<td>14</td>
<td>Promoting cooperation and affiliation</td>
<td>10</td>
<td>14</td>
<td>Organizational capability</td>
</tr>
<tr>
<td>15</td>
<td>Establishing clear goals and plans</td>
<td>12</td>
<td>15</td>
<td>Organizational capability</td>
</tr>
<tr>
<td>16</td>
<td>Information management and protection</td>
<td>7</td>
<td>15</td>
<td>Technological capability</td>
</tr>
<tr>
<td>17</td>
<td>Leadership</td>
<td>16</td>
<td>17</td>
<td>Organizational capability</td>
</tr>
</tbody>
</table>

[Table4-1] Comparison Literature – Interview

As shown in [Table4-1], literature study showed the most importance of ‘laws/institutions establishment’ and ‘technology/service standards’; ‘product/service technology development, creating environment for investment, expanding markets showed relatively significant importance. Interviews suggested the most importance of ‘establishing and supporting operating cost’ and ‘supporting policies’; ‘developing new services for creating profit’ and ‘developing products and service technologies’ showed relatively significant importance.

In both literature study and the interviews, ‘establishing laws/institutions’, ‘developing products and service technologies’, ‘developing new services for creating profit’, ‘creating environment for investment’ and ‘expanding markets’ shows significant importance. ‘Supporting policies’, ‘information management and protection’ and ‘establishing
and supporting operating cost’ showed significant discrepancy from other categories.

![Figure 4-1] Comparison Literature – Interview

<table>
<thead>
<tr>
<th>Literature Study</th>
<th>Correlation coefficient</th>
<th>Significance probability</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.000</td>
<td>.</td>
<td>17</td>
</tr>
<tr>
<td>Rho of Spearman</td>
<td>.610</td>
<td>.009</td>
<td>17</td>
</tr>
<tr>
<td>Interview</td>
<td>.610</td>
<td>1.000</td>
<td>17</td>
</tr>
</tbody>
</table>

[Table4-2] The correlation analysis results (Comparison Literature – Interview)

[Table4-2] shows the correlation analysis results on priorities of CSFs from literature study and the interviews. The correlation coefficient between two studies was 0.610.

4.3 Company competency analysis

Chi-Square Test was used to verify the association between u-City success factors and company competency factors. Chi-Square value was 605.523; degree of freedom was 9; and p-value was 0.000. And u-City success factors and company competency factors showed association, which was shown in [Figure 4-3] below.

![Table4-3] Success Factor – Company Competency correlation chi-squared verification cross tabulation

In achieving each u-City success factor, there were core company competencies, which were shown in the association analysis results below:

- Environmental/institutional factors

  To achieve environmental/institutional CSFs, customer environment, fast-responding markets, customer understanding, strategic planning and practicing capability are important. To actively responding to the institutional chances, consulting and business model development are the important factors.

- Technological factors

  To achieve technological success factors needed for
comprehensive and innovative technologies and services, it is important to develop specialized technologies and R&D activities. Since most services use customer information, information protection and protection technologies are also needed. Technologies for new products and service development are also important.

Chapter 5. Conclusion

5.1 Conclusion and implications

This study examined u-City CSFs from IT company perspective and drew company competencies necessary for achieving the CSFs. Through literature study and interviews with experts, 16 CSFs were identified, each CSF was treated by Frequency Analysis to draw company competencies necessary for achieving each CSF; and the significance on company competencies necessary for successful u-City implementation was proposed. This study concluded with two aspects: CSFs and company competencies.

U-City CSFs from the company perspective implicate 4 aspects through literature study and the interviews:

First, new technology development that brings new values, products and services to the customers is important. Products/services developed for u-City business are still not u-City business exclusive but a mere conversion of technologies and the existing IT services. In addition, u-City technology concepts introduced so far need more time and study before the actual commercialization. Therefore new technology development will bring commercialization and u-City business success sooner.

Second, new service development is needed to create profit for growing u-City business. In case of u-City in Dongtan, substantial service contents are still insufficient for the residents in the area to experience besides a few basic public services, which causes low satisfaction level on overall u-City business and skeptical views on the business. Long-term service development through industry convergence is needed to vitalize u-City business.

Third, cost system should be established for building and operating u-City. U-City Dongtan is complete and using the system, yet it doesn’t have proper financial support. Substantial, consistent new service development is needed to maintain financial support for u-City operation.

Lastly, laws, institutions and governmental support are needed to vitalize u-City business. Local u-City government network-related laws, CCTV laws, outdoor advertising laws, business laws are hindering u-City business. Laws and regulations should be revised to be more favorable to vitalizing u-City business. Various types of support have been made to vitalize u-City business on the government level, which should be consistent and systematic to settle and stabilize the business.

Necessary company competencies to achieve CSFs were drawn from surveys conducted on experts; important company competencies were drawn by Frequency Analysis on company competencies; and the implications below was the results:

First, financial support, government support and profit-generating service development are considered more important than technology standardization and business organization ability for successful u-City business.

Second, large scale investment in urban development, which has been new to IT companies, and understanding of the public demand and market change are considered the most important in operating u-City business.

Third, understanding of market change and the public demand, strategic plans, operating ability, immediate response to the demands are needed to improve government support, laws and institutions.
Fourth, specialized technologies and technology advancement should be maintained.

Fifth, capabilities in various fields are needed to achieve internal success factors of a company.

To summarize the implications mentioned above, IT companies need to secure financial and investment capabilities, which are unfamiliar to many IT companies, to run u-City business. Also, extending the view point from IT perspective to u-City perspective will be helpful to focus more on the public demand. More active involvement with government policies and securing various capabilities should follow in strategic priorities.

5.2 Limitations and further suggestions of the study

Limitations and further suggestions of the study are as follows:

First, more experts are needed in the interviewed companies and the interviews should be done on more companies. Second, this study is limited to u-City industry exclusively in Korea. More studies should be done on various cases in other countries and global companies. Lastly, similar studies not only on IT companies but also on stakeholders of u-City business in various fields should follow to draw more comprehensive results on factor/competency analysis.

Reference


[31] W. C. Hur, “A study on relational analysis model of u-Service for efficient working plan of u-City project”, Yonsei University, 2009


How Will SNS Games Help Social Network Services Grow?
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National Central University, Taiwan
shuwesley@gmail.com

ABSTRACT

By using Social Network Services (SNSs) as platforms, game developers have gathered a huge user base, and the entertainment these games provide has further enlarged the SNS user base. However, there are signs that this symbiotic growth is slowing down.

We developed a model and tested 14 hypotheses. Our main findings are: Although SNSs are "social," "social norms" do not have much impact on the intention to use the games continually. Although users generally are not addicted to SNS games, the creation of addiction is an effective way to achieve continuance.

Keywords: Social Network Service, Social Games, IS Continuance

1. INTRODUCTION

Social network services (SNSs, aka social network sites) have become one of the most popular services on the Internet in recent years. Examples are Facebook, MySpace, Bebo, Twitter, Live Space, and Plurk. According to a recent report, Facebook has become the most popular website in the world as defined by number of visits. This number reached 3.1 billion in 2010, more than Google's 2.6 billion [1].

Data show that the fast growth of Facebook can be attributed to its affiliated games. Facebook has developed a large amount of entertaining game software, which appeared after it launched its platform for third-party applications in 2007. These games have become very popular and in turn helped Facebook attract millions of users.

The growth of SNSs is partially derived from the growth of the SNS games, even though the number of very active SNS game users decreased 5% from April 2010 to May 2010. Thus, in our study we focused on the continuance intentionality and behavior of SNS game users. We begin in Section 2 with a literature review, through which we describe SNS games and the theories our study was based on. In Section 3, we describe our study, including the research model, hypotheses, surveys, and data collection. Section 4 describes the data analyses, including pretests, reliability and validity tests, and hypothesis tests. Section 5 is the conclusion.

2. INTRODUCTION TO SNS GAMES AND LITERATURE REVIEW

2.1. SNS Games

The main difference between SNS games and other games is that the former use existing online social networks to enlarge the user base. This approach benefits SNSs because it enriches their content and makes them a new Internet platform. To keep their customer bases, SNSs and their game partners designed the following four mechanisms:

1. Instantaneity: Almost all the SNSs that host games designate “game zones” that provide game selections and show who is on which game.

2. Invitation: An example is “Restaurant City,” which provides gifts to those who send invitations. Once their friends receive these invitations and become players, the senders can receive free cooking ingredients for every visit by an invitee.

3. Sharing: “Restaurant City” allows players to notify other players about the events they are engaged in. This mechanism creates “ambient awareness” for participants and gives them a good sense of belonging.

4. Recommendation: Many SNS applications allow users to review and rate the applications. For example, Facebook has “like,” which allows users to express their preference for an application. All their friends are notified of this action, which creates a friend-recommended promotion.

However, there are two problems. First SNSs have only recently developed, and 5- or 10-year longitudinal data do not exist. Many domain experts have noticed this trend. The BBC reported a decline in Facebook users in 2008 [2]. In a survey taken at the 2009 Gartner CRM Summit, both the audience and the analysts expected that in 10 years Facebook would have fewer than 250 million users. It had 500 million as of July 2010 [3].

Using its analytic tool called Social Technographics [4], Forrester Research found that the number of SNS users last year dropped in every category except “joiners” and “inactives” [5,6]. Social Technographics divides SNS users into 6 categories, ranging from “creators” to “inactives,” based on how active they are. The percentages of users claiming to belong to the 3 most active categories all dropped. Forrest analyst Jackie Rousseau-Anderson thus suggested that “The initial wave of consumers using social technologies in the US has halted. Companies will now need to devise strategies to extend social applications past the early adopters.” [7] A similar suggestion was made by one of Forrester’s European market analysts [8].

Experts’ worrying is not unique to Facebook. MySpace’s accelerated decline has also been noticed. Between January and February 2011, the number of unique visitors to MySpace declined worldwide by 14.4%, from 73 million to 63 million. Their current audience is only half of what it was a year ago [9].

Data also show that SNS games may be experiencing a similar decline. For example, in 2011 CityVille had 101
million active users (MAUs) in January 2011 but only 97 million in February; in April, the number dropped to 89 million. FarmVille shows a similar pattern. It had 58 million MAUs in December 2010, but only 52 million in February 2011 and 47 million in April [10,11].

Second, SNSs have started to request games that use their virtual money for trading and to charge commissions on the transactions and fees for their commercials. These actions may prevent developers from enaging in free viral marketing and force them to be more cautious in the use of marketing strategies. Thus, we believe that developers probably will need to become familiar with the factors that affect players’ intentions to continually use SNS games and thereby maximize SNS profits. So long as SNS games can continue, SNSs can sustain themselves.

Before demonstrating our model, we present a review of the relevant research literature.

2.2. Information Systems Continuance

Although acceptance of information systems (IS) is the first step toward realizing IS success, the long-term viability and success of an IS depend on its continued use [12]. To explain IS continuance, Bhattacherjee proposed a post-acceptance model based on Oliver’s Expectation-Confirmation Theory (ECT) [12,13].

Oliver believed that consumers’ decisions to repurchase are based on the confirmation of their expectations, which in turn is based on the perceived performance of the product or service after a period of initial consumption. The degree of confirmation determines consumer satisfaction, which is the referent for the repurchase intention. Bhattacherjee believed that IS continuance is similar to consumer repurchasing because both decisions (1) follow an initial (acceptance or purchase) decision, (2) are influenced by the initial use experience, and (3) can potentially lead to ex post reversal of the initial decision. It differs from ECT in the sense that “it focuses only on the post-acceptance variables. This is so because the effects of any pre-acceptance variables are already captured within the ex post confirmation and ex post satisfaction constructs.” Second, “ECT only examines the effect of pre-consumption (ex ante) expectation…; however, continuance is determined by ex post expectation, and ex post expectation is represented by “perceived usefulness.” Studies have shown that perceived usefulness “is the only belief that is demonstrated to consistently influence user intention across temporal stages of IS use”. The extended IS continuance model is schematized in Figure 1.

![Figure 1 Extended IS Continuance Model](image)

3. RESEARCH MODELS AND PROCEDURES

In this section, we begin to describe how SNS games are constructed. We then present our hypotheses based on this description. Finally, we provide the survey data.

3.1. Constructs for SNS games

The extended IS Continuance Model is consistent with research on SNS continuance. First, “self-efficacy” and “facilitating conditions” come from Technology Acceptance Model (TAM) and have proven to be appropriate constructs in various technology studies. Second, our research question is similar to the one that researchers have tried to solve using the IS Continuance Model.

Our model differs from the IS Continuance Model in some respects. First, we use the term “perceived enjoyment” instead of “perceived usefulness.” Not only extrinsic motivation, but also intrinsic motivation, can affect the use of technology in the workplace. Although usefulness is extrinsic, the enjoyment obtained from using IT is intrinsic. Both motives are important in the workplace, but users have no professional goals when playing games and thus usefulness may not be important in this context [15].

Second, we added “socialization” as an ex ante condition. Socialization is similar to “need to belong” [16]. It is the human need for other people to be concerned about one and for one to be accepted by society, or the motivation to establish and maintain long-term, positive, and important personal connections [16]. SNSs are social tools and SNS games can help users fulfill their social needs.

Studies have shown that online game players fall in two categories – power gamers and socializers. Power gamers hope to win, whereas socializers enjoy companionship with their online partners [17]. Most SNS games are designed for light players, and thus socializers may find them more appealing than power gamers.

Social presence is the sense of companionship that is facilitated by the media [18]. Users will find a website useful and enjoyable if they feel a good social presence there [19,20]. SNS games provide a social context in which players can become transfigured into “avatars” that interact with others on the site. Such social presence can lead to a high level of socialization and a better chance of continuance.

Third is the issue of social norms, which are judgments by members of the social group to which one belongs. One’s behavior can be affected by such judgments. It is also likely that social norms affect users’ continuance intentions and behavior.

Fourth, addiction has been reported as a side effect of online social activities [21,22]. Although light players may prefer games that do not require much commitment, addiction can still result in continual playing. Socialization can be another attribute of addiction [23].

Confirmation or disconfirmation is an essential part of the IS Continuance Model. However, we do not believe it is a necessary part of ours. First, confirmation is similar to usefulness. As Bhattacherjee stated, “Though these items [of confirmation] are similar to the usefulness items, usefulness captures users’ expectations from IT usage, while disconfirmation examines the extent to which those expectations are met during actual usage.” [12]. Because the elements of the IS Continuance Model are all ex post, and ex post factors capture the ex ante effect [12], the ex
post enjoyment factor in our model, which replaces usefulness, implies confirmation. Adding confirmation contributes nothing useful, but it could create multicollinearity. The implications of confirmation for enjoyment can also be seen in the measures of enjoyment.

3.2. Hypotheses and the model

Our model, based on the above discussion, is shown in Figure 2.

![Figure 2. 2 SNS Game Continuance Model](image)

The arrows in Figure 2 refer to positive impact. For example, H10 means that the socialization of SNS game players has a positive impact on their enjoyment.

Hypotheses 1, 2, 4, and 5 follow from the extended IS Continuance Model [14]. Hypothesis 3 is based on Jean Morrissey’s observation that addiction can be viewed as continual involvement with a substance or activity. Although the addictive substance or activity is initially sought because it creates pleasure or enjoyment, in the longer term, involvement with it becomes necessary for one to feel normal [24]. Such automatic long-term behavior, which is referred to as a habit, is an antecedent of IS continuance [25].

H6 is based on the Technology Acceptance Model, but “perceived usefulness” is replaced by “perceived enjoyment.” H7 comes directly from TAM.

H8 and H9 are concerned with the factors affecting satisfaction. Research shows that post-acceptance enjoyment positively affects satisfaction [26]. Preece claimed that satisfaction is a determinant of sociability in online communities [20], and Phang proposes that interactivity can provide a way for individuals to obtain benefits such as enjoyment and satisfaction from interactions in the community [27].

H10 and H11 refer to the antecedent of enjoyment proposed by Hassanein and Head and by Lu and Wang [19,28]. H12, H13, and H14, all of which involve addiction, are from Lu and Wang [28].

3.3. The survey

The design of the questionnaire and the preliminary selection of items was guided by our literature review. The scales are socialization, social norms, self-efficacy, facilitating conditions, enjoyment, satisfaction, addiction, continuance intention, and continuance behavior.

The questionnaire has three parts. lists the second part. The first part is a general survey on SNSs and the use of SNS games that we used to screen inappropriate respondents from the test sample. Those who did not play SNS games were excluded. Of the 454 respondents, 239 joined an SNS because of the games. This statistic shows that more than half of SNS users play SNS games. The third part of the questionnaire consists of demographic items, the data from which were used for F-tests to check the effects of demographic differences.

4. PROCEDURE AND DATA ANALYSIS

We began the study with a pre-test to validate the questionnaire. We then conducted the main survey using the validated questionnaire. One-way ANOVAs were employed to check for significant interactions between the demographic and psychological variables. Then, the questionnaire was further validated and model fitness checked. Once all these issues were resolved, the hypothesis tests were conducted.

4.1. The pre-test

The first step of the pre-test was to invite seven scholars with domain knowledge and extensive experience with SNSs and SNS games to examine the above preliminary version of the questionnaire. Two MIS professors checked the internal validity of the questions, and two Ph.D. candidates helped them evaluate the questionnaire further. Five professionals were invited to check for ecological validity, i.e., whether the questions are really important for SNSs and SNS games. All nine judges agreed that the questionnaire “can measure what it is supposed to measure” and that “all dimensions are essential to the evaluation of SNS and SNS games.” Thus, face validity and content validity were achieved.

We then put the questionnaire on Google Docs for the pre-test. Through personal connections such as MSN, Skype, BBS, personal blogs, Facebook and so on, we recruited 147 respondents, 24 of whom were invalid. The reasons for disqualifying questionnaires were: (a) the SNS being used did not have games, (b) the games were not SNS games, (c) the same answer was given to each item; (d) at least one question and its reverse-worded counterpart had contradictory answers, (e) the respondent could not continue playing because of extraneous factors outside the respondent’s control, and (f) the respondent submitted multiple questionnaires (inferred from the same IP address). The sampling started from May 15, 2010 to May 23, 2010.

1. Reliability

Cronbach’s α was used to assess the reliability of the scales composing the questionnaire [19,28]. Guilford has suggested that an α value greater than 0.7 means that the reliability is adequate [29]. Because the reliability was found to be good for all the scales, all the items were retained in the final questionnaire.

2. Validity tests

We began by applying the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy to determine if the scales had adequate validity and were suitable for factor analysis [30]. A KMO score greater than 0.8 shows that the items in a scale have low partial correlations. All the KMO scores in fact exceeded 0.8, which confirms that the scales are factorable.

The factor analysis of the 9 scales yielded 8 factors. After adjustments, there were 9 factors matching the 9 scales.

We repeated the reliability and KMO tests for the new constructs. Both yielded good results (Cronbach’s α = 0.8).
0.738 and KMO = 0.826).

4.2. Main survey
The revised survey was distributed to those respondents who had played SNS games. The survey was posted on Google Docs and remained there for 12 days, from May 26, 2010 to June 6, 2010. The link was provided on several popular Taiwanese websites, including PTT (Telnet://ptt.cc), Gamebase (http://gamebase.com.tw), Gamer (http://gamer.com.tw), and Game DB (www.gamedb.com.tw). Lottery rewards were given and all respondents had an equal chance to win them. This procedure prevented survey bias because, had no reward been given, it is possible that participants who were currently playing SNS games (i.e., did not discontinue playing) would be more motivated than other participants to answer the questions. The total number of questionnaires received was 516, but 64 were discarded due to invalid responses. The reasons for disqualifying questionnaires were the same as those in the pre-test.

4.3. Demographic variables
Because we suspected that demographic variables would interact with the psychological variables, we conducted a series of one-way ANOVAs to test for such relationships.

The overall results show that the demographic factors did not affect the results.

4.4. Reliability, validity tests and model fitness
We follow the same procedure as in the pre-test to test the reliability. It shows that the reliability is good as all the Cronbach’s α values exceed 0.7. KMO value was 0.896, so we proceeded with the factor analysis, which yielded 9 factors corresponding to the 9 psychological dimensions so construct validity is good.

We then conducted convergent and discriminant validity tests. Both were achieved.

We next sought to determine whether our model is the best of the available choices – the question of model fit. The three kinds of model fit (absolute fit, incremental fit, and parsimonious fit) for our data are good.

4.5. Hypothesis testing
Finally, we used maximum likelihood estimation to test the hypotheses listed in Section 3.2. Figure 3 and show the structural equation model for the path analysis and the results of the hypothesis test.

Figure 3 Path analysis for the structural equation model

5. DISCUSSION AND CONCLUSIONS
We showed in Section 1 that the success of SNSs depends on the number of users, which can be increased by providing games. But how is this accomplished? To answer this question, we used a modified IS continuance model to test our hypotheses, with the intention that game developers will be able to draw on our finding to make decisions on strategies to attract more players. Before describing these application-related findings in Section 5.2, we discuss the results of the hypothesis tests in Section 5.1. In Section 5.3, we note the limitations of the study and offer suggestions for future research.

5.1. Discussion of the hypothesis test results
Our study confirms previous studies on the effect of continuance intention on continuance behavior and the effect of self-efficacy and satisfaction on continuance intention. However, facilitating conditions had no effect on continuance behavior. The respondents found it easy to obtain the necessary resources, but this did not increase their intention to keep playing, perhaps because most SNS

game players are light players who do not need large resources to win. It is not a good strategy for a vendor to market SNS games to power players, because this type of players is likely to seek more intensive games in other platforms, such as PS3 games. Thus, we believe that game companies should keep their games as simple as possible, under the assumption that easy entry is a necessary, although not a sufficient, condition for people to play.

The fact that satisfaction was influenced by enjoyment and socialization shows that games are different from other programs. Because data have shown that many people use SNS because of SNS games, the feelings of pleasure from playing SNS games can be an important driving force for the growth of SNSs.

Socialization has a positive impact on the enjoyment of many activities. Simmel believed that socialization brings enjoyment that results from being with others [31]. In real-life social settings, however, socialization can also be associated with pressure or other negative emotions. Because online environments avoid these pitfalls, it is not surprising that they bring enjoyment to game players.

Social norms also have a significant positive impact on

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enjoyment. Lu and Wang point out that enjoyment can be enhanced by playing with friends [19,28]. We can take this further with respect to SNS games. As noted by Granovetter, friends on an online social network include not only members of one’s inner circle or people one has strong ties with, but also people with weak ties – friends of close friends or just people we see only once in a while offline [32]. Thus, the information sharing and interactions among friends on the Internet is more frequent and diversified than among friends in real life. These interactions can intensify the effect of social norms.

Enjoyment also has a strong effect in promoting addiction [19,28]. Addiction in turn results in continuance behavior, as illustrated by our confirmation of H3.

Several hypotheses were not supported in our study. First, we found that socialization and social norms had no significant effect on addiction, and enjoyment and social norms had no significant effect on continuance intention. Because SNSs do not require players to stay online long and their interactions do not have to occur simultaneously, players find the games convenient, but their commitment and social presence are reduced. Because it is likely that players of SNS games need to make a commitment to the games before they become addicted [33], the probability that the games will actually get players addicted is low.

For the same reason, players may demonstrate high levels of socialization in SNS games without becoming addicted. As SNSs themselves are social tools, SNS games are not the only way that SNS users can become socialized.

Neither enjoyment nor social norms were significantly associated with continuance intention in our study. When respondents answered the question about why they quit SNS games or spent less time on them, they said that playing the games was meaningless. A possible explanation is that even though they also said they enjoyed playing the games, most were light players and used SNSs to extend and maintain their social networks. Because there are so many other things both on and off the Internet that can bring them enjoyment, they don’t require SNS games to meet this need.

Although previous studies have found social norms to affect the acceptance of technology, we did not confirm this finding with respect to SNS game continuance. Players’ own feelings (e.g., satisfaction) have much greater impact on continuance intention than the opportunity to interact with friends. When we asked the questions about social norms, we were thinking of close friends, not casual friends. In online social networks, users have different levels of friends, and therefore close friends may not be as important as in other contexts; the players do not need to become engaged with others to the extent that is required in real-life social networks. In addition, there was no evidence in our study for asset specificity, which is defined as the extent to which the investments made to support a particular transaction have a higher value to that transaction than they would if they were redeployed for some other purpose. Perhaps this is because the cost of switching to other games is low. In other words, the friendship one forms in one SNS game does not involve a high level of commitment and thus can easily be replaced by a friendship developed in another game.

We found self-efficacy to be an important factor affecting continuance intention. For example, it is likely that language is a barrier to engagement with both SNSs and SNS games. Once this barrier is overcome, usage increases. In Taiwan, Facebook was introduced in 2006 but did not gain momentum until the Chinese interface was fully built in June 2009. Since then, the number of users has increased from 700 thousand to 2.8 million per month. According to the CheckFacebook report, a number of other countries, including Lithuania, Kuwait, Vietnam, have show similar growth [19,28].

5.2. Research contributions and business implications

Because the history of SNSs is short, research on the subject is in its infancy. Likewise, there has not been as much research on webpage games (i.e., games demonstrated and played on webpages with no peripheral devices) as much as on other Internet activities or even video games. Nonetheless, there is evidence that SNS games are an important driver of SNS growth. We hope that our research will be valued as a pioneer in this emerging but important area.

1. According to Businessweek, gamification has become a priority for businesses such as Siemens, Hilton, Nissan, and Target [34]. Gamification is the use of game-playing mechanisms for non-game applications, particularly consumer-oriented web and mobile sites, with the aim of encouraging people to adopt the applications [35]. Our study falls in the gamification category. Because industry practitioners have started to notice the increased use of gamification, our research findings about which aspects of gamification are the most important should be of direct benefit to companies. The factors we found to be important, such as “enjoyment,” are the ones that companies may want to invest in more: It can be seen in Figure 3 that the most significant path in the model is from “enjoyment” through “satisfaction” to “continuance intention”. However, there was no significant relationship between “enjoyment” and “continuance intention.” Finding the game to be interesting is not sufficient grounds for players to continue playing SNS games; they need satisfaction. An important reason for this satisfaction is the inherent value of the games: more gain for less effort [36]. FarmVille is a good example. Players can get a good sense of achievement by watching their crops grow without spending much time on it.

2. Social norms had little impact on continuance compared with other factors. Even though respondents indicated that they were influenced by friends (see average scores for males and females in Table 7), and friends had little effect on how much they enjoyed the games, social norms had no direct impact on continuance intention. Thus, although Facebook has a larger user base than other game platforms, and players may have more friends playing with them, these factors did not necessarily lead to continual use of SNS games. Facebook might be able to form a monopoly due to network externality, but that does not mean it will necessarily be able to monopolize SNS games. Other SNSs will still have a good chance to compete in
the market by providing good-quality games.

3. One way to increase one’s continual use of something is to become addicted to it. In our study, we found that the average “addiction” score was 2.58 (錯誤！找不到参照來源 *) . This figure indicates that SNS games have not yet gotten players addicted. Although excessive addiction is morally reprehensible, what matters most is keeping a balanced perspective on any products that have a negative impact on us. Game companies can add more competition, challenge, and feedback to increase the likelihood that players will continue playing.

4. Although self-efficacy increased continuance intention in our study, other variables had a greater effect on it. The average self-efficacy score was above 4.0, which indicates that the respondents found SNS games easy to play. It is unlikely that simplifying the games further will increase the probability that players will keep playing.

We believe that the IS Continuance Model, which our study was based on, needs to be modified in two respects. First, “confirmation” needs to be removed from the model, at least when applied to SNS games, because it is subsumed under “perceived enjoyment”. Second, we used “perceived enjoyment” instead of “perceived usefulness,” because usefulness is not relevant to why people play SNS games; instead, enjoyment is the issue. Finally, we added “socialization” to the model, as well as other dimensions specific to SNs, and we found that most had an impact on IS continuance.

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Study on Factors Influencing the Intention of Organization to Acquire Service-Oriented Architecture: Focusing on Domestic Firms

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Abstract

The SOA adoption is expected to bring a significant paradigm change in IT industry as the Client/Server architecture did from a terminal based architecture in the past. OSA is becoming a public attention because of its business agility and IT cost reduction benefit on today's business environment of growing diversity and convergence among various businesses. But since the SOA adoption level in Korea is still in early stage, many companies have difficulties both in setting a strategy and direction for adopting SOA and in achieving a goal of adoption SOA successfully.

So, this research investigates the factors which determine the decision of SOA adoption. The proposed model in this paper was developed on the basis of the innovation diffusion theory, fad theory, and rational efficiency theory.

For the study, six independent variables are selected: two organization variables - IS flexibility, Organizational innovational two environment variables - bandwagon pressure, market uncertainty two perceived characteristic variables - perceived benefit and risk of SOA. And one control variable is selected; strategic typology.

Chapter 1 Background and Purpose of Study

In today's dynamic and steep business environment, influence of IT is expanding every [75]. Also, today's companies are facing unprecedented, revolutionary change in business environment. Globalization, deregulation, emergence of new technology, increased flexibility of customers and more intense competition require fast change from companies. Because of interchange between different systems and fast development of diverse and new products that satisfy customers' needs by increased change and cooperation in business environment, ability to change flexibly to domestic and foreign environmental change is becoming the key of business competitiveness. [43].

Therefore, business requirements and IT requirements not only make it possible to use the IT-based structure more effectively, but also it requires technology that can combine with practical solution and be equipped with adaptation and flexibility that can follow the continued change and development to business process and business model.

However, most of the solutions to synchronize technology and business work conditions so far have been skewed to technical side, and focusing on application programs, so they do not provide business flexibility. [7].

Most notable company IT architecture to respond to such business demand effectively is 'Service-Oriented Architecture: SOA'. SOA is a paradigm that can seek IT efficiency and maximize business outcome by reusability and standardization as well as agility and flexibility by reconfiguring functions present in Silo system to Service structure in business and IT perspective, register into registry and make it possible for reuse in several clients. [7]

Recent IT product suppliers had reached standards consensus on SOA and main web service standards, and SOA is becoming reality thanks to emergence of new tools and base structure that enable SOA and service possible as reusable and interchangeable on all platform. [50]

Gartner said “transformation to SOA will bring change in the frame of thinking that can be comparable to that from terminal-based architecture to Client/Server architecture, and by 2008, 80% of the new development projects will be SOA” [12]. Also, Forrester Group analyzed that SOA had already become a critical part of IT [46], but Ovum’s dire prospect that says SOA-based projects would mostly fail in three years [28]. Also, extreme shrinking of IT investment following economic downturn is the most obstacle of SOA adoption. Likewise, domestic level is still in initial phase in the midst of hope and worries, and many companies have difficulty over forming strategy on SOA adoption, and since there are worries on SOA itself, such as process speed on outcome and security, there are suspicions on meeting the goal [28].

In order to alleviate suspicion on SOA, SOA must be settled as a means to combine business and IT, rather than a mere IT architecture. However, even though a company established a system based on SOA, industrial experts explain that there is few site that materializes the initial ideology of developing necessary service and recycling for the necessary service through sharing process.

This is the point to ask a question: “Disregarding the advantages that were emphasized when it appeared in market, is SOA in stalemate of failed?” Some say that, unlike SOA's failure to satisfy the expectations, the industry sees potential for new development of SOA by unifying with some trends of the software market. An argument that emergence of new computing methods with service concept will open a new road for SOA is dominant. One IT expert says that “It is appearing that SOA is a key value to provide a service concept to the new popular software development and delivery methods like SaaS, cloud computing and BPM.” In other words, SaaS and cloud computing adopt service as software development and delivery method, so as these concepts stand out in the market, SOA's utility will be increased. Particularly, SOA will be a useful concept to support reduction of cost, which is a key value presented to customers by Saas and cloud computing.

In order to introduce new information technology and strategy successfully for a company, planned and continual activities to lead change in members’ thinking and behavior and recognition of new technology as innovation must accompany, and it is studied that adoption of such innovation is influenced by environmental, organizational.
and adoption objects’ contexts. [18] To understand decision factors of the organization’s information technology acceptance, there needs much effort [65]. Recently, the subject of research is changing to the factors related to realization of IT in the organization. For example, there have been studies on what correlation exists between organizational variables and information technology to lead successful realization of IT [17, 45]. In this regard, it is focusing on recognizing SOA as a type of innovation, developing research model based on innovation model and realizing SOA adoption intention.

By taking a look at context of SOA, most influencing variables on SOA adoption are sought, intention of adoption depending on the company’s inside and outside context is studied, and the strategy to expand SOA is sought. Analyzing the variable influencing SOA adoption intention has huge meaning as it decides SOA’s development direction and business strategy. Also, the factors influencing domestic firms to introduce SOA are systematically analyzed, and through deduction of generalized adoption factors, a tactics to expand and settle SOA as company’s strategic competition tool will be presented. By checking influencing factors that need to be considered while introducing SAO, and by studying the chance and necessity of SOA by companies that plan to introduce SOA and SOA vendors, adoption strategy specific to each company’s environment will be devised and factors that do not play positive function will be realized or removed, to contribute to transforming to positive function.

Today’s information technology has critical influence on business success. Therefore, organizations use such information technology to increase effectiveness of organization. Thus, study on adopting and expanding technology-based innovation is necessary [26]. Empirical study with theoretical and statistical verification and based on innovation research’s outcome on existing IT and information system, fundamental reason to introduce SOA is sought from IT innovation perspective, and factors that have positive or negative impact on SOA adoption are to be recognized. In order to meet the goal, research model on SOA adoption intention is developed, and main factors that influence companies to introduce SOA are presented.

In this research, along with theoretical study on SOA, through study on existing research over the factors influencing selection of innovation-perspective information system based on theories related to information system and new technology selection, theoretical basis will be gained for building structural model. The study is consisted of the following five chapters.

In chapter 1 ‘Adoption’, study’s background, purpose, method and structure are sought, and in chapter 2 ‘Theoretical Background of Study’, SOA concept and previous studies on technology adoption are covered. In chapter 3 ‘Study Model and Hypothesis’, empirical study model is presented, and hypothesis for empirical analysis through operational definition of factors and factor analysis to set measurement model is presented. In chapter 4 ‘Empirical Analysis and Verification of Hypothesis’, data collection and sample selection process for verification of the set hypothesis are shown, and hypothesis is verified. In the last chapter 5, ‘Conclusion’, limit and implication of study is presented, as well as the summary.

Chapter 2 Theoretical Background of Study

Clause 1 SOA (Service-Oriented Architecture)

Companies have so far been responsible for huge cost of integration and system maintenance due to expansion of different-model solution. Also, they have had difficulty upgrading the disparately separated system when necessary. In order to grow in the changing business environment, it is necessary to transform to RTE with ‘on time perception’ and ‘quick response’ as key. Also, with emergence of such concept, a necessity of integrated environment in which application and data are quickly accessible is growing. So, companies have gained business requirements to achieve agility and cost effectiveness [76].

Also, as a wall among previously invested applications (ERP, CRM, SCM, etc.) is made, lack of compatibility appeared. This is not a merely technical issue, but for business execution and interaction with other business, a wall is made on the method companies use for IT [6]. The IT subjects for companies to satisfy the business model necessity is as follows [7].

- Maintenance of consistence IT architecture that adapt to changing environment
- Making clear and easy application development environment
- System that is easy for support, expansion and restoration
- Development of recyclable program
- Immediate finding of reason and solution when problem emerges
- Setting business logic’s architecture
- IT structure that supports change and minimizes shock

Such IT requirements not only make IT-based structure efficient, but also it requires technology that can successfully integrate with flexible, adaptive and practical solution to follow the continued change and development of business process and model. However, most applications to synchronize technology and business condition are skewed to technology and focused on application program.

Therefore, it is necessary to find company approach to allow business leaders and IT at mid-point. In order to secure business and architecture framework that can connect the issues of business, rather than method to overcome technical incompatibility, necessity of SOA is emerging [6].

The term SOA is first used by Prof Alexander Pasik in 1994 to explain the difference of Client/Server model in dispersion environment and the traditional model [40], and SOA, an acronym of Service Oriented Architecture, has no standardized definition yet, but there are technical and business point definitions exist [6].

In Gartner, it is defined that “SOA is a concept of standard interface, and software architecture that establishes total application” [57, 67], and OASIS defines that “SOA organizes business logic dispersed in different domains, and by using it, new service is created and SOA is a paradigm to create a new service from those services.” [48]

In Web Service Architecture Working Group of W3C, He defined SOA as “Service Oriented Architecture is an architectural style whose goal is to achieve loose coupling among interaction software agent” [34]. In this, Loose Coupling means that it is not necessary to know the
application’s technical specifics in order for an application to talk to other conversation. This includes that platform must be independent, and neutral to programming language. Furthermore, it includes that it must follow the mature standard. Even if it has complete platform, language and independent interface, in order to achieve loose connection in real meaning, an authoritative rule that everyone acknowledges is necessary.

In SOA, service means a unit of service provided to customers, as business task that can be repeatedly used. SOA must exist autonomously while each unit of logic is not isolated and interacted. Therefore, logic unit must comply with principles, but evolve independently while maintaining community and standard [23].

Bieberstein et al. suggests advantage of SOA adoption as recycling of component, and SOA's flexibility as reduction of cost, time and effort, solution of IT problems by flexible solution and reduction of realization time, and differentiation of business competitiveness and justification of IT investment through close connection of IT and business service [6].

In the research by Yoon and Carter, advantage of SOA adoption is classified as improved business agility and lowered costs. Improved business agility includes quick response of IT to business environment, chagne of market or customer demand, easy system integration, stronger connection of IT and business, improvement of data flow and improvement of customer service. Lowered costs include reduction of application development cost and time, reusing existing functions, reduction of installation cost and maintenance cost [76].

IBM proves through IBM SOA method that advantage of SOA adoption is increase in agility, quick response to change, reduction of cost, improvement of effectiveness, business management and application of new technology [38].

Gartner anticipates “Change to SOA will bring change in frame of thinking comparable to that from terminal based architecture to Client/Server architecture, and 80% of the new development project by 2008 will be SOA [12]”. Also, Forrester Group analyzes that SOA has already become an inseparable part of IT. [46].

Domestic adoption of SOA is slower than other advanced countries. On this, the situation of domestic market in which systematic and active approach is less sufficient than American and European states where many success stories and detailed achievements are found. In 2007, SOA gained most attractions in every IT area like system management, ERP and BPM, in domestic IT industry. Especially, like in overseas cases, in domestic cases too, all communication companies adopted SOA to conduct projects, and in financial, public, manufacture and service sectors, adoption is being considered. In case of communication industry, not only in management, sales and fee charge, but also in SDP (Service Delivery Platform), which provides new product service by interacting with IP network and previous network like Internet phone and IPTV based on IP, SOA is expected to be introduced [27].

Clause 2 Concept of Innovation

Damanpour defined that innovation is development of tool, system, policy, program, process or product inherently in organization or adoption of them from outside [18]. Amabile defined that, by attempting connection of individual creativity and organizational innovativeness, organizational innovation is successful execution of unique idea in organization [4]. Also, Rogers defines that innovation is idea, practices or objectives newly recognized by individual or other selection unit. Therefore, response to innovation could be perceived differently by individual objectives. [65]

Innovation can be classified into three types. First, it is technology innovation, which means creation of innovation where no product or service exists before. Secondly, it is a process innovation, calling improvement of existing product or service and making it with new method. Lastly, it is administrative innovation, which is an innovation that makes and emphasizes new organizational design. New organization will support new product and service effectively. Management innovation includes information management system. [35].

Also, innovation’s types can be classified into the following three. First, incremental innovation means improving function or adding it to the existing product or procedure; secondly, synthetic innovation means integrating existing idea or technology to make new product or service. Lastly, Discontinuous innovation is making new product or service not existing before [30].

Clause 3 Spread of Innovation

3.1 Rational-Efficiency Theories

So far, the effective perspective, which has been mainstream in study on spread of innovation, has set decision making of each company in economic environment, in which declining outcome creates pressure of organizational change and search, as rational self decision. However, effective perspective can explain only part of spread of innovation for the following reason. First, the premise of introducing management innovation methods following the Pro-innovation biases can explain accelerated spread only partially, and it cannot explain the reasons of not accepting effective innovation in the organization and spreading non-effective innovation methods, well[1].

Secondly, the complete-information assumption which says that spread of innovative method causes the introducer recognizes the technical achievement following adoption of innovation is unrealistic in phenomenon, while theoretically making sense.

Thirdly, the perspective of benefit and cost of assuming incomplete information perception is based on an assumption that as there are more entities introducing the method, the cost will be decreased and achievement improved, so more firms will introduce. In other words, decision makers calculate the outcome of introducing innovation correctly, so the information on efficient innovation must be delivered from early adopter to late adopter via some channel. [13] However, in order to verify the efficiency, it takes some time, so late adopter cannot wait for the outcome, and not only it can prove the presence of specific channel where the information exchange taking place, but also early adopter has no reason to spread the information of innovation in competitive nature. [2]
According to Rational-Efficiency Theories, innovation is a main source of profit or economic benefit, and the important purpose of innovation is to get economic profit like maximize profit, promote market share and secure competitive superiority [1].

3.2 Fad Theory
An organization copies other organization when the reason or method of the problem to be solved is uncertain or understanding of technology is vague [20], and it is an argument that it works as a strong myth as spread to many organizations. Increase in organizations which adopt the innovation influences the organizations which have not taken innovation yet, but soon to do so [49]. Innovation is selected and spread not because of its effectiveness, but it becomes natural to adopt it due to social norm, so organizations cannot help but bandwagon. Through this process, spread pressure is created. As the number of adopters increase, the pressure increases, and the increased pressure in turn increase the number of adopters. [52]

Rumelt analyzed the argument that organizations suggested by Chandler adopt multiple business organizational structure in order to solve management issue of diversification strategy, and he found that it has correlation from 1940s to 1960s, but the reason is not related to efficiency [66]. The result implies that in initial phase of innovation spread, organizations select innovation to solve the facing problem, but in later phases, there could be other reasons [2]. Organization theorists tried to find the reason from Bandwagon pressure. Bandwagon pressure means that in later innovate phase, the organizations which want to adopt innovation continue innovation while not having recent information its efficiency or profitability, and this asserts pressure to adopt innovation to other organizations as more organizations adopt it in initial phase [2]. In other words, bandwagon means a process of spread of innovation due to pressure of bandwagon by many organizations which adopted innovation, rather than to gain efficiency or profit. [2, 73]

3.3. Innovation Diffusion Theory
Innovation diffusion theory gives useful view to explain the phenomenon in which new information technology is accepted and used, so it is used as a standard theory of many empirical researches on selection and spread of information technology by individual or organizations.

Diffusion theory is closely related to technical innovation, most used by not only anthropology, sociology, education, marketing and also by technical innovation. Spread of innovation can be defined as increase of adopters of an innovation through communication after time, by social system like individual group or other units. [65]

Rogers says that levels of adoption of innovative goods is innovators, early adopters, early majority, late majority and laggard. Innovation diffusion theory emphasizes the importance of the group which buys new product early. In other words, the purchase behavior of innovators who buy new products early influences early adopters’ behavior, and early majority copies early adopters’ reaction after observing it. Therefore, the early adopter group, which plays a role of opinion leader, plays big role of spread of new products by leading potential adopters’ imitation [9]. Rogers argues that there are the following factors of innovation diffusion’s contexts.

- Relative advantage: Degree of perceiving innovation is better than the existing one
- Compatibility: Degree of perception of compatibility of innovation with existing one in value, necessity and previous experience
- Complexity: degree of difficulty to use the innovation by user
- Triability: degree of attempt and test before accepting innovation by user
- Observability: degree of observing innovation from others

Especially the perceived usefulness and easiness used by TAM (technology acceptance model) are same as relative advantage and complexity, and Davis (1989) adopted these from diffusion theory [3, 56, 59, 71].

Tornatzky and Fleische suggests theoretical TOE framework used for research of adoption of technical innovation [74]. Through this, the factors influencing the innovation adoption process are suggested as External Environmental Context, Organizational Context, and Technological Context. External Environmental Context has relevant industry, competitor, regulation and relation with government as main variables. Such variables are factors existing outside of the company that provides limits and opportunities to technical innovation. Organizational Context means the context of general company like size of company, degree of centralization, standardization, complexity of management structure, quality of personnel, and size of resources to use from inside of company. The factors are company’s structure and process that limit or promote adoption and execution of innovation. Technological Context is how technological contexts influence the adoption process.

Thong and Yap developed integrated model on information system adoption by small-sized firms, based on technological innovation literature [72]. The model sets CEO context as innovation on information selection, and organizational context as company size, competitiveness and information strength.

Premkumar and Roberts conducted research on usage of various communication technology and the factors influencing selection of the technology by rural companies. They divided innovation, organization and environmental contexts, and included total of 10 variables [63]. After empirical analysis on 78 companies in the U.S., comparative advantage, support from CEO, organization size, competition pressure and outside support are found to be important variables.

Grover researched how uncertainty of environment and ripeness of inner information system, the organization’s structural factor and factor to outside environment, influence innovation technology adoption. The uncertainty factor found that innovation technology is accepted due to outside pressure, and the organization is influenced by dynamics of outside environment, degree of competition environment and difference of environment to accept innovation [26].

Iakovou et al. conducted research by dividing the factors influencing EDI adoption among small-sized firms with three criteria [37]. It points ‘outside pressure on adoption’ by low status of small sized firms, organizational
preparedness on technology and resources, and ‘perceived benefit’ limitedly perceived by small sized firms due to lack of usage and integration, are important factors.

Burgelman et al. defines company’s innovation capacity as ‘combination of organizational context that can promote and support innovative strategy’, and suggests a model to evaluate innovation capacity [10]. There are two categories: injection factors necessary to devise innovation strategy and structural and cultural factors that can influence execution of the devised innovation strategy, and detailed variables on each are suggested. For detailed variables, as injection factors, degree of securing resources, capacity to understand competitor’s innovation strategy, and capacity to understand technological environmental change, and as organizational factor that influences strategy execution, organizational cultural factor and management’s innovation acceptance capability are pointed.

Kimberly and Evanisko classified the variables influencing technology innovation acceptance, rather than management innovation, as individual, organization and environmental variables. The variable used as decision making factor of adoption is leader’s context (experience, academic history), organizational context (centralization of decision making, possession of expert personnel, size of organization, diversification of functions) and environmental factor (competition). After empirical research on hospitals, organizational factor is found to have more impact on degree of innovation than individual and environmental factors [44].

Chapter 3 Research Model and Hypothesis

Clause 1 To Set Research Model and Hypothesis

1.1 Research Model

According to the definition of innovation, defined by many researchers in previous researches, the SOA to be discussed in this study can be regarded as innovation. Since it is creation of new service, it can be Technology Innovation, and since it improves the existing information system’s function, it can be seen as Incremental Innovation.

Adoption of information system can be classified into individual level adoption and that of organizational level, and this study focuses on organizational level adoption, regarding SOA adoption as a company’s decision.

Combining the previous studies, it is found that the factors influencing technology adoption in organization commonly consider Organization Context, Environment Context and Technology Context, presented by Tornatzky and Fleische’s TOE framework.

Unlike individual level adoption of innovation, that of companies must accompany many changes in basis and process of the company, in addition to huge amount of investment, so it uses organizational context, environmental situation and innovation context as basis of decision for general decision making. Also, perceived context of the technology subject to innovation is included as variable. Therefore, this study also adopts organizational, environmental and technology contexts, proved of their importance by previous studies, as dimensions.

At the same time, based on rational efficiency theory, as variables of organizational context, flexibility of information system and innovation of IT organization are included. Given that SOA adoption’s advantage is flexibility, the fundamental purpose of introducing SOA could be flexibility. Therefore, it is deemed that when flexibility of information system is harmed, intention to introduce SOA is created, and this is added.

Among outside company contexts, based on trend theory, bandwagon pressure and uncertainty of management environment variables are included. Bandwagon pressure is a pressure of adoption from the company which introduced SOA. Company adopted SOA vary by industries like communication and financial sector. With this in mind, it is judged that bandwagon pressure inside the industry is judged to have influence on SOA adoption intention. Also, as management environment becomes uncertain, more accurate information is needed and reliance on information system increases. So uncertainty of management environment is prospected to have influence on SOA adoption intention.

Among the perceived contexts of SOA, based on the majority of theses that say perceptions have decisive importance on organization’s decision making, SOA’s perceived advantages and risk variables are selected. For adjustment variables, information system building strategy types are selected, to check adjustment effect between independent and dependent variables.

In this study, based on the previous study on technology adoption intention decision, research model to verify the relationship among factors influencing SOA adoption intention in the organization is presented like

[Picture 3-1] Research Model

1.2 To Set Research Hypothesis and Operational Definition of Variable

1.2.1 Flexibility of Information System

IS flexibility can be defined as system capacity to adapt effectively to the changed in and outside conditions [9]. Satisfaction on flexibility and expansion of existing system is important factor in motivation of change. If satisfaction on current system is low, a new method to increase outcome is devised [14]. In Chau and Tam’s study, it is studied that current system’s high satisfaction has negative influence on open system adoption intention [14].

The most advantage that organization can acquire through SOA adoption is flexibility [6]. If the organization’s information system has high flexibility, it will feel less necessity of SOA, but if the flexibility is low,
it is expected to actively seek adoption of SOA. Thus, the following hypothesis is presented.

**Hypothesis 1: High IS flexibility of organization has negative impact on SOA adoption intention**

1.2.2 IT Organization’s Innovativeness

There are many studies on spread of innovation, and the unit of choosing innovation is not individual but group. Therefore, a certain tendency to innovation in organization, or innovativeness must be measured or compared, and it reached an agreement that such innovativeness must be treated as analysis unit. Through initial studies on organization’s innovativeness, the characteristics of organizations with strong innovativeness are found to have same level of innovativeness with individuals. [65]

Innovativeness of IT organizations is self-oriented motive to introduce new technology, and according to Kim, and Prabhakar [42] and Gefen [24]’s studies, innovative users prefer new technology or new business or trust them. This argument is supported by Lewise et al. [47]’s study.

In Donthu and Garcia’s research, online customers tend to be innovative without considering risk factors existing the new transaction way, and pursue new and diverse experiences. Based on this, organizations with innovative tendency prefer new information technology, so it is inferred that they will risk, trust and accept new technology [21].

IT innovativeness means fast decision making process and intention to introduce new technology, and willingness and support from management part means conferring decision making authority or directly participating in adoption or application of new technology.

It calls the degree of accepting new products in advance to other members by individual or unit. So, innovative adopter is a type which takes risk in initial phase of innovation spread, while adopter with low innovativeness avoids risk and reduces expected loss. Therefore, as innovativeness is higher, it will adopt innovation faster and more actively.

**Hypothesis 2: IT Organization’s innovativeness has positive impact on SOA adoption intention**

1.2.3 Bandwagon pressure

In the research of Abrahamson and Rosenkopf, it is explained that adoption of innovation is done continuously, fearing loss of competitive advantage. Such reason forces pressure to adopt the innovation by other groups as more organizations adopt it in initial phase. This is called bandwagon pressure. Bandwagon means a process of adopting innovation by bandwagon pressure from many organizations, rather than to do so in order to gain effectiveness or profit [2, 73]

Bandwagon pressure can be divided into institutional bandwagon pressures and competitive bandwagon pressure. Institution bandwagon pressure is a pressure from fear of not getting legitimacy or support from the community the organization belongs or interested parties if not adopting innovation. Competitive bandwagon pressure is a pressure from fear of possible degradation of organization’s outcome below than average if not adopting innovation, while groups of the same industry have adopted the innovation. Also, many researchers of information system argue that it is likely to adopt new information technology introduced in the industry, if the technology is regarded as threat to competitors [41, 62]

If SOA’s domestic adoption status is taken a look at, large companies of financial and communication sectors lead the adoption. From this, a hypothesis of presence of bandwagon effect in the industry can be set.

**Hypothesis 3: As bandwagon pressure is higher, it will have positive influence on SOA adoption.**

1.2.4 Uncertainty of management environment

The uncertainty of the environment, related with the level of market change and the impossibility of expectation, means the causal relationship between environmental elements is uncertain because the important information about company or products and some activities are not correctly known [36]. As the result, the company has much difficulty in expecting and controlling the flow of necessary resources. That is, much information is needed for the company to make some decision, but such information does not work in many cases due to the complexity of environment and uncertainty of expectation.

Pfeffer and Leblebicis said that the organization of a company placed in comparatively stable environment related with the environmental characteristics can perform given tasks without the help of sophisticated information technology, but in case of environment rapidly changing and complex, it needs much information technology because it needs the help of the information technology for analysis and management of uncertainty. The organization comes to have the necessity and the appropriateness of introducing information technology in the floods of external environment complex and rapidly changing. Besides, many innovation studies claim that external environmental factors such as the uncertainty of environment promote the innovation. It is because when an organization encounters an environmental change complex and rapid, the information system is essentially required [61].

Chenhall, Morris and Duncan also made similar claims. They explained that the more uncertain the environment of company is, the bigger does the forecast comprehensive and future oriented related with external situations than detailed information of interior, that is, the necessity of external information about the related external companies and customer behavior become, and as the result, the introduction of information system follows that [15, 22].

Miller and Friesen classified 52 manufacturers into conservative and entrepreneurial, and proved that the product innovation of two companies according to environmental change of management has a positive correlation [55].

Grover and Goslar emphasizes the uncertainty of environment as a variable effecting the technology introduction of company [26].

Iacovou said the uncertainty of environment has relevance to the environmental characteristics of product. The environmental characteristics of product includes the life cycle of product, the development cycle, the velocity of development cycle and the velocity of change for customer demand, etc. and because such environmental characteristics of product are related with the products and the services which the company is making, it plays a
positive role of promoting the introduction of new information system [37].

The organization recognizes the necessity of change to counter and adapt to external management environment, and it obtains the information and the resources needed during the innovation process from the environment, so the organizational environment which individual companies face has an important effect on the innovation [11, 29, 55].

Since the uncertainty of management environment seriously affect the strategy of company, the business performance and the usage of information technology, the uncertainty of environment can be considered to be an important factor among the environmental characteristics of companies.

1.2.5 Perceived advantage of SOA

In deciding human behavior, the emphasis on the decisive importance of perceptions and the study started from Chicago School of society. Thomas and Znaniecki(1927) stressed the importance of the perception saying “If people perceive situation as reality, that exist in their ends”. Not attributes classified by experts or change workers, the perception about the innovation attribution of consumers themselves affect the rate of acceptance.

The perceived interest means the potential interest caused by building and using new information system of company, and in many previous studies, the interest perceived classified in many perspectives of perceived interest is explained to affect positively the introduction of information system.

Pfeffer and Leblebici classified the perceived interest largely into direct interest and indirect interest, and the direct interest includes the reduction of transaction cost, the increase of cash flow, the reduction of stock level, the improvement of information level, the increase of operational efficiency and the increase of decision-making efficiency, etc., and the indirect interest includes the differentiation of product and service, the improvement of customer service, the relationship improvement between transaction parties, the increase of competitiveness, the increase of market share and the enhancement of image etc... [61].

Chau and Tam used perceived benefits in the part of characteristics of technology innovation of open system studying the factors affecting the introduction of open system [14]. They proposed benefits that the open system does not need specific license system, can select hardware and software more freely, can use well the resources of information technology and can access transparent data.

Based on the above mentioned previous studies, we develop the following hypothesis.

Hypothesis 5: If the perception level of perceived benefits is higher, it will have a positive effect on the introduction of SOA.

1.2.6 Perceived risk of SOA

The perceived risk is subjective uncertainty of adopter about the result of adopting activity. That is, to set as function relationships of importance of uncertainty and adoption results, the perceived risk discussed here means the risk adopters subjectively perceive even though risk exists practically and objectively. Thus how the adopter perceives the innovation during the decision-making process of innovation introduction affects decisively in forming the attitude of preference or non-preference and leads to whether to introduce the innovation or not [39].

The adopter of innovation perceives the innovation attributes but the risk together, so it affects as much as the advantages of innovation on the adoption process of innovation, and it can explain more clearly about what decision-making the adopter takes to decide the introduction of innovation. If the introduction of innovation occurred in spite of high perceived risk, this introduction of innovation can be presumed not to be an adoption by rational decision.

Generally if the perceived risk about new innovation is high, the possibility of adoption is reduced, so the perceived risk and introduction activity can be considered to have a negative effect on the intention of introduction [64].

Chau and Tam used the perceived barrier in the feature item of technology innovation of open system in studying the factors for the introduction of open system. They said, using the fact that open system has many options as an example, barriers of selection lurk as many as [14].

SOA should perform additional tasks such as communication network in case of method call, XML document generator and package of protocol XML document due to web service usage. Such additional tasks have a negative effect on the capability of entire IT infrastructure [70]. Furthermore setting the level necessary for security also can be quite difficult task [16].

One major problem SOA has independently can be that the processing speed can slow above all. Because of this, banks or other institutions regarding processing speed important are unwilling to introduce SOA. The issue on security is also a big obstacle. Since in SOA environment many services are connected, it is possible to generate risk factors on security. The customers which unconditionally order SOA project when business requirements are not analyzed clearly are being pointed out as a problem.

As projects are performed when SOA is not understood exactly, there are some cases which has little effect and only growing management burden. In addition, as IT organizations lead most SOA projects, there are other cases that they cannot derive support of work-site during analysis-decision process [28].

Beimborn and Joachim divide the risks of SOA into technological uncertainty, capability and security [5]. When realizing SOA generally web service standards such as SOAP and WSDL are used[60, 77], this is used universally but W3C still classifies it as immature stage [8]. Based on the above mentioned previous studies we develop the following hypothesis.

Hypothesis 6: If the level of perceived risk is higher, it will have a negative effect on the introduction of SOA.
1.2.7 IS strategy types

The company strategy can be defined as the whole course of exploring, confirming and redefining the communication method with management interaction [53]. This is the definite plan for accomplishing the goal of company and the plan for the company to adapt to changes inside and outside environment and it includes the plan for innovation of management structure to adapt as the whole company to the change of business environment and the plan for coping with the diversification of market.

A representative research about the type of organization strategy was performed by Miles and Snow [54]. Miles and Snow assumed that one can simplify the complexity of strategic process by classifying the action type of organization and classified the strategy types of company from a strategic viewpoint for effective harmony between organization and environment maintaining the interdependence within the organization. Theses are divided into ‘Defender’ stressing the cost effectiveness, ‘Prospector’ stressing the innovation, ‘Analyzer’ giving priority to quality, and ‘Reactor’ reacting to market situation without special strategy. This classification is not only the most influential, the most refined and the most widely used, but also the organization classification verified experimentally [19, 31-33] [51] [58] [68, 69]. The types of organization strategy of Miles and Snow has a strength to clearly explain the form countering the management environment as relationship of strategy, structure and process [25]. The characteristics of each type are as follows:

First, Defender is a strategy focusing on searching for the stability of organization and is a favorite for companies belonging to mature industry. It searches for methods to defend the position in market by effective production, strong control mechanism continuity and reliability etc. The companies adopting this do their best in stable environment, are cost-initiated, specialize them on specific areas and maintain the low cost structure using existing standardized technology process. In addition, as the environment change where these set in is slow, the defensive strategy can rely on long-term plan.

Second, Prospector is a strategy that companies searching for method to look forward to new opportunity, new product, service and market adopt. It copes with the environmental change elastically, develops new products and actively pioneers new market. The core technology is at marketing and research and development, and it wants to have wide range of technology and product form. It gives priority to the development of new product and service and the innovation, meets the ever-changing customer needs and generates fresh demand.

Third, Analyzer is a strategy that companies evading excessive risk and focusing on new product and service choose. It concentrates on limited range of products and technology and searches for method to hold a dominant position in competition with other companies based on quality enforcement. The analyzer type maintains the effectiveness of existing products and service at any cost and maintains the flexibility to pursue new business action. Searching for technological effectiveness to maintain low cost structure and emphasizing the development of new product and service at the same time, it maintains the competitiveness in case of market change [53, 54].

This study adopts the strategy types of Miles and Snow as control variables, and develops the following hypotheses:

- Hypothesis 1-1: The effect that the flexibility of information system has on the introduction of SOA will be different by business strategy types.
- Hypothesis 2-1: The effect that the innovation of IT organization has on the introduction of SOA will be different by business strategy types.
- Hypothesis 3-1: The effect that the jump pressure has on the introduction of SOA will be different by business strategy types.
- Hypothesis 4-1: The effect that the uncertainty of management environment has on the introduction of SOA will be different by business strategy types.
- Hypothesis 5-1: The effect that the perceived benefits have on the introduction of SOA will be different by business strategy types.
- Hypothesis 6-1: The effect that the perceived risk has on the introduction of SOA will be different by business strategy types.

Chapter 4 Conclusion

To verify the hypothesis, the effect that the innovation of IT organization, the flexibility of information system, the jump pressure, the uncertainty of management environment, the perceived benefits of SOA and the perceived risk have on the variable of adoption intention of SOA will be confirmed by multiple regression analysis.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Operation Definition</th>
<th>Items</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent variable (Likert5-point rating scale)</td>
<td>SOA introduction intention</td>
<td>SOA introduction intention</td>
<td>Chau &amp; Tam (1997), (2000)</td>
</tr>
<tr>
<td></td>
<td>SOA favor Degree</td>
<td>SOA favor Degree</td>
<td>Tung &amp; rieck (2005)</td>
</tr>
<tr>
<td>Independent variable (Likert5-point rating scale)</td>
<td>Flexibility of IS</td>
<td>System capability to meet changed internal/external requirements and to adapt quickly and effectively</td>
<td>Chung (1996)</td>
</tr>
<tr>
<td></td>
<td>SOA introduction intention</td>
<td>Integration possibility of information system Other task feasibility of information system Connectivity with information system inside/outside company Rapid change of information system Easy change of information system</td>
<td>Agarwal &amp; Prasad (1998), Agarwal &amp; Karahanna (2000)</td>
</tr>
<tr>
<td></td>
<td>SOA introduction intention</td>
<td>SOA favor Degree</td>
<td>Reich &amp; Benbasat (1990), Abrahamson (1991)</td>
</tr>
<tr>
<td></td>
<td>Flexibility of IS</td>
<td>New technology preference tendency Curiosity about new technology and service Effort not to be behind the times</td>
<td>Grover &amp; Goslar (1993)</td>
</tr>
<tr>
<td></td>
<td>IT organization innovation</td>
<td>Spontaneous motivation to introduce new technology</td>
<td>Chau &amp; Tam (1997), (2000)</td>
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<td>Jump pressure</td>
<td>In case some organization does not adopt innovation when many organization in same industry adopt innovation, degree of pressure by fear that the organization outcome may fall below average due to that</td>
<td>Reich &amp; Benbasat (1990), Abrahamson (1991)</td>
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<tr>
<td></td>
<td>Uncertainty of management environment</td>
<td>Degree of difficulty in identifying changes in customer feature and preference</td>
<td>Grover &amp; Goslar (1993)</td>
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<tr>
<td>Control variable (Nominal Scale)</td>
<td>Information system building type</td>
<td>Future direction of companies for surviving competition and maintaining dominant position and decision-making or process related to effective distribution of limited resources</td>
<td>Miles &amp; Snow, et al. (1978), Sabherwal &amp; Chan (2001)</td>
</tr>
</tbody>
</table>

**Variable**

- Dependent variable (Likert5-point rating scale)
- Independent variable (Likert5-point rating scale)
- Control variable (Nominal Scale)

**Operation Definition**

- SOA introduction intention
- SOA favor Degree
- Integration possibility of information system
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- Connectivity with information system inside/outside company
- Rapid change of information system
- Easy change of information system
- New technology preference tendency
- Curiosity about new technology and service
- Effort not to be behind the times
- Degree of difficulty in identifying changes in customer feature and preference
- Degree of awareness about benefits by companies building and using SOA
- Degree of perception about danger caused by companies building and using SOA
- Future direction of companies for surviving competition and maintaining dominant position and decision-making or process related to effective distribution of limited resources

**Items**

- SOA introduction intention
- SOA favor Degree
- Integration possibility of information system
- Other task feasibility of information system
- Connectivity with information system inside/outside company
- Rapid change of information system
- Easy change of information system
- New technology preference tendency
- Curiosity about new technology and service
- Effort not to be behind the times
- Degree of difficulty in identifying changes in customer feature and preference
- Degree of awareness about benefits by companies building and using SOA
- Degree of perception about danger caused by companies building and using SOA
- Future direction of companies for surviving competition and maintaining dominant position and decision-making or process related to effective distribution of limited resources

**Reference**

- Tung & rieck (2005)
- Reich & Benbasat (1990), Abrahamson (1991)
- Grover & Goslar (1993)


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PORT STRATEGIES FOR THE NEW ECONOMY: AN EMPIRICAL INVESTIGATION

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ABSTRACT

The proposed study is designed to measure primarily sea-based and secondarily land-based logistical links that support merchandise related trade in Asia & North America at a macro-level. The method and instrument development are based on macro-level published data. For further development, data will be collected using surveys, field observations, and interviews conducted in the United States, Korea, and China; and conceptual discourses within and beyond the research team will be used to develop conclusions. To our knowledge this is the first study to apply AHP to measure global port competitiveness along two dimensions: ‘customer-facing’ competitiveness as well as ‘investment-attracting’ competitiveness.

Keywords: AHP, Empirical, Port, Logistics

INTRODUCTION

From the time of the pioneer sailing on April 26, 1956 of Ideal-X, the first containership, from Newark, New Jersey, international trade and transport have been transformed through containerization. The result has been an alteration of the geography of production and distribution according to the 2007 Conference CFP “Globalization and Freight Transportation in a Containerized World”, available at: http://www.gfptt.org/Entities/EventProfile.aspx?list=all&idx=56217a8-ee8-4847-8e34-a1499c156391, accessed on March 1, 2007, with Asia becoming the global center for all types of manufacturing and service creation. Starting with Singapore, Hong Kong, and Busan, many Asian ports have taken full advantage of containerization and associated inter-modal transport methods to create some of the world’s most efficient and competitive ports [22], [23].

In recent years, Asian merchandise trade has grown at a rate higher than the rate of growth of global trade in North America and Europe (see Table 1). Within Asia, of course, the main driver of merchandise trade is China where imports as well as export growth rates in recent years have hovered around 25 percent per year (see Table 1). While merchandise trade growth rates are high for Europe, trade among the European Union member states accounts for most of this growth. Asian trade, on the other hand, is directed significantly outside the region although intra-Asia trade is also growing. Table 2 further dramatizes the very high levels of North America and Europe-linked merchandise trade from China and Korea. In 2005, Asia’s North America and Europe-linked trade was about $1.1 trillion dollars while North America’s and Europe’s combined Asia-linked trade was about $600 billion dollars.

### TABLE 1

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<td>43.0%</td>
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<td>7.5%</td>
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### TABLE 2

<table>
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<tr>
<th>Merchandise Trade from (Billions, 2005)</th>
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<td>Europe</td>
<td>608</td>
<td>498</td>
<td>1424</td>
</tr>
</tbody>
</table>


Asia’s merchandise trade with North America and Europe is increasing faster than the planned capacity expansion for ports located in those regions. This means that the probability of supply chain interruptions due to port capacity constraints is also heightened. To mitigate these emerging imbalances and potential interruptions, several initiatives have been undertaken, or are being contemplated [7], [8], [9], [10]:

- Extreme pressure on the Long Beach port in California is spawning initiatives to enhance East Coast and Gulf ports in USA, and to increase volumes to Canadian ports, with surface transport of some of the goods to USA.
- China’s development push in its own western region has shifted container volume to inland Yangtze ports - with Shanghai as a hub. This is necessary since 90% of China’s international trade is handled through marine transport.
The intense transshipment competition between major East Asian ports such as Busan and Shanghai has led to major investments in port capacities.

Middle East ports such as Dubai Jebel Ali, Jeddah, are making continuing efforts and Aqaba to upgrade and to become transshipment centers not just for Middle East/Africa but also for South Asia – capturing some of the expected growth through Busan and China.

China has launched aggressive plans to upgrade the infrastructure of its remote western regions by building a major highway link from its western provinces to the Pakistan port of Gwadar.

Busan has consistently increased its berth capacity among its five member ports to discourage competition and maintain competitive service levels.

The European Union, with the support of agencies such as Geneva-based International Road Transport Union (IRU), is making concerted efforts to improve transportation infrastructure by developing regular road-rail, inter-modal links, via northern and southern routes, to western China.

To mitigate the increased costs and decreased service levels at some US ports, the Panama Canal widening project has prompted private firms to invest in increasing capacities on the US Gulf and East Coast ports such as Houston, Savannah and Charleston.

These initiatives are designed to mitigate the anticipated capacity imbalances that could potentially interrupt important supply chains, harm trade, and weaken national economies. This leads to the first research question:

Will the existing actions by ports improve their competitive positions? Will the improved competitiveness result in the expected outcome of mitigating supply chain disruptions and attracting new container volume?

The underlying general research question is the following:

What are the factors on which ports compete? How can ports manage their congestion and growth so as to become and remain competitive?

**LITERATURE REVIEW**

The literature on how ports compete has primarily addressed port competition from the viewpoint of the customer (customer-facing) within a country or region [10]. Other studies either do not specify the context for their findings (i.e., whether the findings apply within a specific region or on a global scale) or they address only a few of the competitive factors (e.g., [3], [12], [13],[14], [17]. Collectively, these studies identified five major factors affecting port competition from the viewpoint of a customer. These include port location, cargo volume, service level, port facility, and port expenses (lowest cost or price). In the [10] model, the authors expressly exclude port expenses because the accounting practices in the Chinese ports they studied were heterogeneous – making meaningful comparisons difficult. In this study, the variable ‘port expenses’ were included as a subjective factor so that Port Competition can be measured in a more robust manner. Based on these studies, we adapted general definitions for each of the five competitive factors. Greater levels of each of the following factors are considered to make a port more competitive:

1. **Actual Cargo Volume (not capacity):** Carriers and port users view major ports that handle large volumes of containers as preferable. Total volume combining import, export, and transshipment cargo appears to be more important than any single category of volume.

2. **Port Facility Capacity:** Port facilities are defined as all tangible assets that are used to service water-borne cargo. Capacities of these assets are of particular importance to liners and carriers since ports operate during peak and off-peak periods. They include infrastructure, superstructure, and labor assets.

3. **Port Location:** Location factors include geographical distance from production facilities, ease of port and berth entry, potential for expansion, and quality of inter-modal access.

4. **Service Level:** The percentage of cargo that will be off-loaded/loaded within the port management’s promised time period (variance of time promised), as well as the average off-load/load time. This includes operation during peak periods and in adverse weather conditions.

5. **Cost Competition:** The cost to the liner per TEU for load/off-load service as well as applicable port duties. From the viewpoint of a liner/user, Cost is a surrogate for port efficiency – so efficiency will not be measured separately [10].

Perhaps the most important issue with Asia-linked trade today entails the second factor listed above – Port Facility Capacity – because the existing 10,000, 14,000, and planned 18,000 TEU post-Panamax vessels require 16-21 meter, deep draft, multi-berth container ports [21, Module 2, Pg. 41, Box-12]. Currently, neither the US nor Busan (Korea) or China ports can handle all of these vessels when fully loaded [5]. From the viewpoint of a customer/user, this could be especially problematic for developing countries because their fast growth and steady shift to world-class manufacturing will rely on developing reliable and efficient supply chains. These efficiencies will necessarily involve accommodating the larger vessels. Supply chain interruptions – caused by inadequate scale

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**The 11th International DSI and the 16th APDSI Joint Meeting, Taipei, Taiwan, July 12 – 16, 2011, pp.206-213**
and efficiency of ports – would severely hamper developing countries competitiveness. Other well-known Asian-port rivalries (e.g., Busan-Shanghai, Singapore-Dubai) are motivating these mega-ports to improve their competitiveness for transshipment business by planning to build the capacity to handle the larger vessels. Berths at Busan’s new port are currently being planned to accommodate larger ships.

In addition to the factors considered important to a customer (customer-facing competitiveness), the literature identifies factors affecting port competitiveness for resources (e.g. FDI and/or governmental funding). We group these factors under the label of “investment competitiveness”. These competitive factors are heavily influenced by public policy and could be used to shape public policy [21]. These factors are:

1. Legal Framework: This entails the degree of autonomy of port management, including its own judiciary, to work outside of political arenas (similar to US Administrative courts) and the specific agreement between central and local governments describing the powers of port officials.

2. Institutional Structure: The management structure should be conducive to investment (Private Sector ports), with proper autonomy and have a cooperative relationship with labor. The labor force should be sufficient and well trained. Table 3 demonstrates the four major port management structures and spells out how they differ with respect to the control over port assets and activities. They are Public Service Ports, Tool Ports, Landlord Ports, and Private Sector Ports. Table 4 describes each management structure – including its strengths and weaknesses. At the extremes, Public Service ports are operated as not-for-profit entities whose primary goal is public service; while Private Sector ports operate solely in the interest of the investors – with the government abdicating its rights for any public good.

3. Financial Resources: Autonomy to use port revenue for maintenance and expansion, maintain healthy cash flows, and the capacity to raise funds when needed.

4. Port Reputation: The use of a mechanism, such as a port sector regulator, to ensure fair competition among the various entities that compete in ports. This involves preventing anti-competitive practices that often take place with port monopolies.

5. Price: The price that ports charge for basic services including container handling, premiums for peak periods, and storage fees.

The literature suggests that the public policy factors are key factors for a port’s competitiveness for investment income. Investment sources include local private, foreign direct investment (FDI), local governmental, central governmental or federal, and international agencies or intergovernmental.

### TABLE 3

**Port Management and Operations by Port Type**

<table>
<thead>
<tr>
<th>Port Management or Aspect</th>
<th>Port Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Public</td>
</tr>
<tr>
<td>Administration</td>
<td>Public</td>
</tr>
<tr>
<td>Nautical Management</td>
<td>Public</td>
</tr>
<tr>
<td>Infrastructure – Nautical</td>
<td>Public</td>
</tr>
<tr>
<td>Infrastructure – Port</td>
<td>Public</td>
</tr>
<tr>
<td>Superstructure – Equipment</td>
<td>Public</td>
</tr>
<tr>
<td>Superstructure – Buildings</td>
<td>Public</td>
</tr>
<tr>
<td>Cargo Handling</td>
<td>Public</td>
</tr>
<tr>
<td>Pilots</td>
<td>Mixed</td>
</tr>
<tr>
<td>Towing</td>
<td>Mixed</td>
</tr>
<tr>
<td>Mooring</td>
<td>Mixed</td>
</tr>
<tr>
<td>Dredging</td>
<td>Mixed</td>
</tr>
<tr>
<td>Inter-modal Connections</td>
<td>Mixed</td>
</tr>
</tbody>
</table>

Note: Mixed – A combination of Public and Private

Source: [21, Module 1, Pg. 9, Box-5]

### TABLE 4

**Port Types, Missions and Orientations (available on request from authors)**

Source: Adapted from World Bank Report, 2007

The results of the literature review answers the first research question:

What are the factors on which ports compete?
How can ports manage their congestion and growth so as to become and remain competitive?

This study finds that there are ten factors measuring two dimensions of port competitiveness. Included in these ten factors are variables measuring a port’s ability to attract new investments. New investments in port infrastructure lead to reduced congestion and provides resources to manage growth.

### METHODOLOGY

The Analytic Hierarchy Process (AHP) is one methodology used in decision-making. Its strength is its ability to utilize both quantitative and qualitative criteria in the same analysis. Saaty [16] developed the concept of AHP, defining it as “…combining both subjective and objective assessments or perceptions into an integrative framework…” based on ratio scales from pair-wise comparisons. Wedley [20] described the techniques associated with AHP in the following three steps:

1. Structure a network hierarchy
(b) Making pair-wise comparisons to yield priorities
(c) Synthesizing the priorities into composite measures of the decision alternatives or options.

According to [10, pg. 11] “…due to its applicability in business decision-making, resource allocation, priority rating, and performance evaluation problems, AHP has been used in a variety of studies. AHP application example can be found in [2, 4, 15, 18].” A useful feature of AHP is its applicability to measuring intangible and tangible criteria through ratio scales. In addition, by breaking problems into separate elements and relating them in a hierarchical, logical manner beginning with a single high-level decision – descending in a step-wise manner to lower-level criteria on which the decision will be made. A decision-maker is able to relate the higher-level to the lower-level criteria through a series of pair-wise comparisons [19].

Several studies have applied AHP to maritime decision-making [10]. For example, Frankel [10] applied it to shipping policies, and [11] to shipping liner competition. These studies, however, are limited in that they only utilize the methods analytical and conceptual elements. Haralambides [5] applied an advanced version of AHP, called fuzzy set logic, to model shipper choice in international shipping. This pilot study applies AHP to an empirical investigation of port competitiveness. The data were collected from expert academics, port directors and managers, shippers, carriers, and public officials. Next, a description of the application of the AHP stages to contain port competition among Asia, Europe, and the United States is made to measure perceived competitiveness using upper and mid-level objectives.

Step 1: The Decision Hierarchy

The first step required for AHP analysis is to establish a network structure. This can be done by:

(a) Identifying the ultimate goal or decision on the top of the hierarchy
(b) Establishing one or more mid/lower-level objectives that are the criteria to evaluate the goal
(c) Link the criteria to specific variables on which the criteria are measured
(d) Finally, listing identified alternatives on the bottom, which are linked with the higher level variables, criteria and the ultimate goal of the decision

The ultimate goal of this study is ‘Port Competitiveness’, which is positioned at the top of the hierarchy. Next, mid-level goals are ‘Volume Competitiveness’ and ‘Investment Competitiveness’. The third level involves the variables and attributes of port competitiveness, which will be identified using empirical techniques and the literature. These are listed in the middle of the network structure. Finally, specific container ports in countries such as India, Asia, Europe, and the U.S. – the port alternatives – are listed at the bottom of the network. Figure 1 illustrates the conceptual framework for port competitiveness derived from the AHP method as described above.
pretesting and pilot testing survey instruments to ensure reliability prior to administration to a full sample.

To pretest the instrument, it was administered to a convenience sample of experts and port administrators through an organization called the Global University – 8 (GU8). The GU8 is a consortium of eleven international universities located on ocean ports. The purpose of the organization is to encourage global research on issues related to international trade. Member institutes include The University of Rhode Island (US), Inha University (Korea), LeHarve University (France), Xiamen University (China), Washington University (Seattle, Washington, US), University of Hawaïi (US), The Royal Melbourne Institute of Technology (RMIT-Australia), Hull University (GB), Haifa University (Israel), and Meiji University (Japan).

While invitations were sent to ten GU8 members, 28 experts and managers, representing eight ports, agreed to participate. They are Busan Port (Korea), the port of Los Angeles/Long Beach (US), port of LeHarve (France), Port of Incheon (Korea), Port of Chennai (India), Port of Mayaguez (Puerto Rico), Port of Melbourne (Australia), Port of New York/New Jersey (US).

RESULTS

The following tables report the results of the AHP analysis and the respondent profiles. The Continuity Index (CI), which measures the logical consistency of the results, was .8, which is less than the critical value of 1.0. Any CI exceeding 1.0 is considered logically inconsistent [10].

### TABLE 5
Port Affiliation & Position

<table>
<thead>
<tr>
<th>Port Director</th>
<th>Elected Official</th>
<th>Port Senior Manager</th>
<th>Researcher</th>
<th>Shipper</th>
<th>Carrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Busan (Landlor d Port)</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>LA/LB (Landlor d Port)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>NY/NJ (Landlor d Port)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Melbourne (Tool Port)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Chennai (Landlor d Port)</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Incheon (Landlor d Port)</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Mayaguez (Landlor d Port)</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>LeHarve (Tool Port)</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>No Specific Port Affiliatio n</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

### TABLE 6
Volume Competitiveness - Pair-wise Comparison matrix, weights, & priority

<table>
<thead>
<tr>
<th>Cargo Volu me</th>
<th>Port Facili ty</th>
<th>Port Locati on</th>
<th>Servi ce Level</th>
<th>Port Cost</th>
<th>Weig ht</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cargo Volum e</td>
<td>1</td>
<td>5.33</td>
<td>.445</td>
<td>95</td>
<td>.885</td>
<td>.807</td>
</tr>
<tr>
<td>Port Facilit y</td>
<td>1</td>
<td>.848</td>
<td>2.544</td>
<td>2.14</td>
<td>.171</td>
<td>4</td>
</tr>
<tr>
<td>Port Locati on</td>
<td>1</td>
<td>3.269</td>
<td>2.88</td>
<td>2.28</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Servic e Level</td>
<td>1</td>
<td>3.05</td>
<td>6</td>
<td>276</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Port Cost</td>
<td>1</td>
<td>.184</td>
<td>3</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### TABLE 7
Investment Competitiveness - Pair-wise Comparison matrix, weights, & priority

<table>
<thead>
<tr>
<th>Price</th>
<th>Instituti onal Structur e</th>
<th>Legal Structur e</th>
<th>Financi al Resour ces</th>
<th>Port Reputation</th>
<th>Wei ght</th>
<th>Prior ity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>1</td>
<td>1.245</td>
<td>1.49</td>
<td>1.43</td>
<td>1.434</td>
<td>.163</td>
</tr>
<tr>
<td>Instituti onal Structur e</td>
<td>1</td>
<td>2.158</td>
<td>2.178</td>
<td>2.184</td>
<td>.246</td>
<td>1</td>
</tr>
<tr>
<td>Legal Structur e</td>
<td>1</td>
<td>1.768</td>
<td>1.595</td>
<td>.153</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Financi al Resour ces</td>
<td>1</td>
<td>2.10</td>
<td>.243</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Port Reputation</td>
<td>1</td>
<td>.195</td>
<td>3</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### TABLE 8
Overall Values of Volume Competitiveness

<table>
<thead>
<tr>
<th>Cargo Volu me (1.184)</th>
<th>Port Facili ty (1.171)</th>
<th>Port Locati on (2.82)</th>
<th>Servi ce Level (2.76)</th>
<th>Port Cost (1.184)</th>
<th>Over all Val ues</th>
<th>Ranki ng</th>
</tr>
</thead>
<tbody>
<tr>
<td>Busan</td>
<td>0.501</td>
<td>1</td>
<td>0.375</td>
<td>0</td>
<td>0.309</td>
<td>9</td>
</tr>
<tr>
<td>LA/Lon g Beach</td>
<td>0.141</td>
<td>5</td>
<td>0.161</td>
<td>0</td>
<td>0.285</td>
<td>6</td>
</tr>
<tr>
<td>LeHarv e</td>
<td>0.131</td>
<td>3</td>
<td>0.124</td>
<td>0</td>
<td>0.111</td>
<td>2</td>
</tr>
<tr>
<td>Incheon</td>
<td>0.090</td>
<td>0</td>
<td>0.150</td>
<td>8</td>
<td>0.093</td>
<td>5</td>
</tr>
<tr>
<td>NY/NJ</td>
<td>0.033</td>
<td>2</td>
<td>0.146</td>
<td>7</td>
<td>0.052</td>
<td>0</td>
</tr>
<tr>
<td>Chennai</td>
<td>0.027</td>
<td>2</td>
<td>0.02</td>
<td>0</td>
<td>0.03</td>
<td>0</td>
</tr>
<tr>
<td>Melbour ne</td>
<td>0.032</td>
<td>1</td>
<td>0.010</td>
<td>4</td>
<td>0.045</td>
<td>5</td>
</tr>
<tr>
<td>Mayagu ez</td>
<td>0.043</td>
<td>0</td>
<td>0.012</td>
<td>0</td>
<td>0.071</td>
<td>4</td>
</tr>
</tbody>
</table>

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This means that 58.5% of a shipper’s, or 3PL carrier’s decision to select a port is based on where the port is located, relative to the destination of the cargo, and whether or not a port can off-load or load the cargo within the promised time period. This finding is important because it suggests that ports are not selected primarily based on port costs, meaning that shippers do not view them as commodities in the supply chain, but as value-added assets. However, since ports can’t be physically relocated to improve the Port Location variable, the finding that it is important does not help administrators at existing ports to make better decisions. It does mean that port directors should focus resources on reducing the time it takes to off-load and load containers in order to improve service levels. This does not mean that port costs can be ignored, accounting for 18.4% of shipper’s decision, costs must still be in line with other similar ports. This variable increases in importance in areas where viable alternatives exist, such as Korea, China, and Puerto Rico, and less important where viable alternatives do not exist, such as LeHarve, and Melbourne. Using these criteria on the eight selected ports, Busan is the most competitive port in the world for improving volume, followed by LA/LB and Incheon. This finding is supported historically as Busan has increased annual container volume at a rate that has kept it ranked as one of the top five ports in the world, second only to Chinese ports, which were not represented in this study.

**Investment Competitiveness**

Based on the results reported in Table 7, Institutional Structure (.246) is the most important factor for potential investors, followed closely by Financial Resources (.243). Together they explain 48.9% of an investor’s decision. However, the minor differences in weights of .003 suggest both factors are of practically equal importance to an investor. Port Reputation (.195), Price (.163), and Legal Structure (.153), while less important, collectively account for 51% of an investor’s preference of port investment. This suggests that potential investors prefer ports that are strong in all five factors of Investment Competitiveness, rather than a few dominant variables.

In relative investment competitiveness values, reported in Table 9, Incheon (.1089), LA/LB (.1075), and Busan (.1073) are equally attractive for investors. This is because all three ports have strong weights on all five factors. NY/NJ (.614) and LeHarve (.456) are third and fourth, with Chennai, Mayaguez, and Melbourne practically tied for the least attractive for investors. This suggests that the last three ports must make significant changes in their ability to reinvest funds in port infrastructure, improve practices that increase competition for services to capture new investment funds, and develop legal systems to efficiently and quickly resolve disputes between stakeholders.

**Investment Competitiveness vs. Volume Competitiveness**

In evaluating the overall scores for investment versus volume competitiveness, volume competitiveness was

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**TABLE 9**

Overall Values of Investment Competitiveness

<table>
<thead>
<tr>
<th>Port Competitiveness</th>
<th>Volume Competitiveness</th>
<th>Investment Competitiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port Location (.282)</td>
<td>Port Facility (.171)</td>
<td>Cargo Volume (.326)</td>
</tr>
<tr>
<td>Service Level (.76)</td>
<td>Port Cost (.136)</td>
<td>Price (.103)</td>
</tr>
<tr>
<td>.2640</td>
<td>.0987</td>
<td>.0368</td>
</tr>
<tr>
<td>NY/NJ (.614)</td>
<td>LeHarve (.456)</td>
<td>Melbourne (.402)</td>
</tr>
<tr>
<td>.1089</td>
<td>.1075</td>
<td>.1073</td>
</tr>
<tr>
<td>Incheon (.1089)</td>
<td>LA/LB (.1075)</td>
<td>Busan (.1073)</td>
</tr>
</tbody>
</table>

**DISCUSSION**

The weights and overall values reported in Tables 5 to 9 are summarized in Figure 2.

**FIGURE 2**

AHP with weights and overall values

Volume Competitiveness

Based on the results in Table 6, Port Location (.282) is the most important criteria in the competitiveness of global ports. Service Level (.276) is a close second, followed at a distance by Port Cost, Port Facility, and Cargo Volume.

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The 11th International DSI and the 16th APDSI Joint Meeting, Taipei, Taiwan, July 12 – 16, 2011, pp.206-213
found to be slightly more important representing 50.14\% of overall competitiveness. However, the two factors are practically of equal importance, which is logically consistent in that the most competitive ports are attractive to both shippers and investors. This may explain why Busan and LA/LB have demands on their ports that consistently exceed capacity and why Incheon has achieved strong growth in a relatively few years of operation. These results address first research question.

Will the existing actions by ports improve their competitive positions?

The results show that the activities of Busan, LA/LB, and Incheon are improving their competitive positions. However, the remaining ports must make substantial improvements in Service Levels and all five factors of investment competitiveness to become competitive with the larger ports.

Will the improved competitiveness result in the expected outcome of mitigating supply chain disruptions and attracting new container volume?

Strong volume competitiveness suggests that investments in infrastructure have a high probability of attracting new revenue and the associated returns. Increased investment in infrastructure leads to increased port capacity and decreases the probability of disruptions. Increased capacity also leads to higher service levels – resulting in greater volume.

The finding that Port Location is the most important factor in volume competitiveness is consistent with previous research, e.g. [10] that tested similar variables in a Chinese context. However, it differs with some US-based research, e.g. Grigalunas [5], that found that Cost was the most important factor. These differences could be contextual since there are container port alternatives in the Northeast US and China that may encourage Cost competition, whereas regions with few alternatives may consider Port Location the most important factor. The finding that Service Level is the second most important variable differs from previous research, e.g. [10], that found Port Facility was second, along with other factors, e.g. [5]. Also, the difference between the first and second priorities is less in this study than [10] or [5]. This suggests that a balance in all five factors increases competitiveness greater than dominance of one or two factors. The reason for these conflicts could be due to the difference in sampling frames, i.e. [10] measured Chinese ports exclusively. These studies tend to compare ports within a single country or geographical region. In contrast, this study examines port competitiveness on five continents – a more diverse sample. Therefore, the way ports compete within a geographical region could be different than when competing on a global basis. This may explain why a greater balance in port capabilities is important to improve competitiveness. Another possible explanation is the small sample size used in this study. This suggests that the observed differences are due to random chance rather than a true difference in samples. A third possible explanation for the differences is that this study is the first to simultaneously test investment competitiveness and volume competitiveness. This suggests that investment competitiveness accounted for some of the variance previously accounted for by volume competitiveness.

LIMITATIONS

This study is severely limited due to its small sample size; however, since the primary purpose is to develop and pilot test a new measurement instrument, the sample size is appropriate. The final sample will be 200 ports worldwide. While the results are not fully consistent with previous research, major findings, such as Port Location being a top priority, suggest that the instrument is valid and reliable. While several blocking variables were measured, such as port type, the small sample size restricted testing these factors.

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EFFICACY OF PURCHASING ACTIVITIES AND STRATEGIC INVOLVEMENT: AN INTERNATIONAL COMPARISON

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ABSTRACT

This study examines the effects of purchasing activities and the purchasing function’s involvement with corporate strategy on manufacturing competitiveness as it is affected by national differences. In particular, we are interested in the research question: Do purchasing theories built on samples from mainly North American and Western European countries apply in other countries with different cultural contexts? The statistical results provide evidence that the engagement and efficacy of purchasing activities and strategic involvement within companies vary by national culture. A particular cultural dimension, Long-term orientation, is significantly related to the efficacy of purchasing activities and strategic involvement. This finding will enable top managers from different nations to adopt and implement purchasing activities with the realization of how those activities could lead to different outcomes.

Keywords: Purchasing, supply chain, national culture.

INTRODUCTION

Over the last two decades, the role of the purchasing function has been well recognized as a central component of the operations strategy of a company [9][28][33][39][44][49]. What is missing from the literature, however, is a thorough understanding of effects that national influence may have on purchasing activities and how this affects manufacturing performance. Despite cautions from many studies, the extant operations management (OM) literature often assumes that theories developed based on USA or European data are universal and, though with no empirical support, applicable to other countries [14][19][32][36][59]. From the perspectives of both research and industry practice, ignorance of national differences can be misleading. For instance, Hofstede [19] found that many applications of management theory have failed even with the most experienced international companies due to cultural misunderstanding. In support of this, using Chinese samples, Zhao et al. [59] found that a manufacturing strategy theory developed using North American data may not be applicable to Chinese firms.

The effects of national differences on purchasing activities have been noted but not properly studied and/or validated [28][36][41][43]. Often, purchasing studies have examined the issue of national differences using very limited data that were collected from a single country or two countries for comparison [3][5][36]. Moreover, national difference is often treated as a control variable, while its explanatory influence on purchasing activities is not well understood. Yet it is vital that managers responsible for global operations understand how resident managers, based in different countries, make different decisions affecting purchasing activities [3][43]. The overarching objectives of this study are, therefore, to validate previous findings showing cultural differences in purchasing activities and to further the understanding of how national differences influence the efficacy of purchasing activities on manufacturing performance.

The particular research question we intend to address is whether purchasing theories, though well grounded in the literature, are, in fact, universal and applicable to countries with distinct cultures. Specifically, using data collected from 511 manufacturing plants, we investigate the relationship between purchasing activities (including the implementation of purchasing activities and strategic involvement of purchasing functions) and manufacturing competitiveness performance across two culturally distinct country groups, Western Europe/USA and Asia. The following section reviews relevant literature pertaining to several frequently cited purchasing activities and strategic purchasing involvement and their importance to manufacturing performance. Research hypotheses are developed, followed by the presentation of research methodology, including samples and measurements. The statistical results and discussion in relation to national differences are presented. Finally, managerial implications and suggestions for future research are provided.

THEORETICAL DEVELOPMENT

Based on the purchasing literature (see [6][9][27][33][38]) and the suggestion from Dr. Phillip Carter, the Director for Advanced Purchasing Studies, at the Institute of Supply Management, this section selects and reviews several purchasing activities that are frequently discussed and implemented in the industry. This list of purchasing activities encompasses various practices related to procurement, supplier development and supplier involvement. For each purchasing activity, we review its impacts on various aspects of manufacturing performance, including cost, quality, delivery, and flexibility. We also review the effect of purchasing strategic involvement as suggested by previous studies [30][33][51].

Purchasing Activities (PA)

described buyer-sponsored supplier conferences as meetings with the firm’s suppliers that cover such issues as expectations for the suppliers, as well as issues relating to the long-term supplier-buyer relationship. The involvement and importance of buyer and seller collaboration is evident in the literature. Several studies cited supplier conferences as a critical activity that enhances supplier and buyer collaboration and manufacturing performance [5][6][8].

b. Formal strategic sourcing process. Narasimhan and [33] and Talluri and Narasimhan [49] emphasized the importance of the strategic sourcing process that involves careful selection of suppliers, development of long-term relationships, and implementation of a continuous feedback system between buyer and supplier. The strategic sourcing process includes insourcing and outsourcing decisions, both of which contribute greatly to delivery performance [6][48][50].

c. Reverse auctions. Reverse auctions allow buyers to make purchases by observing a series of bids from sellers [13][47]. Supply chain partners around the world can get connected using web-based electronic reverse auctions. Carter et al. [6], Essig and Arnold [13] and Rhea [42] confirmed that e-procurement programs with e reverse auctions could lower purchasing transaction costs, as well as increase opportunities for the purchasing function to produce value for the firm.

d. Supplier representatives in plant. McIvor and McHugh [31] identified supplier representatives in plants as assisting in two areas—purchasing and new product introduction. Suppliers could become members of cross-functional teams within the organization with their added benefit dependent on their level of participation and fellow team members’ willingness to work with the supplier representative [33]. Womack and Jones [57] suggested that having supplier representatives housed in manufacturing facilities helps to quickly reduce response time associated with problems and mitigates negative effects. Specifically, with regard to new product development, utilizing supplier representatives reduces risks and resources, increases knowledge and its sharing, and reduces product-to-market time. Sara Lee Co. experienced a five-fold increase in process innovation with the use of in-plant supplier representatives who provided quicker and more accurate feedback on quality and innovation [1].

e. Strategic alliances/partnerships. A strategic alliance is a formal partnership between at least two firms that contributes to the strategic objectives of each firm (Pearson et al., 1998). Strategic supplier alliances and partnerships can become competitive advantages through the development of long-term mutually beneficial relationships [8][24][33][54]. In general, a long-term strategic relationship would allow for informal communication that can expand the involved companies’ knowledge of competitive issues through greater discovery and disclosure of information.

f. Commercial procurement software (e-procurement). Electronic procurement, often thought of as web-based procurement, includes web-based enterprise resource planning (ERP), e-sourcing, e-tendering, e-reverse auctioning, and e-informing [6][26][44]. Benefits of e-procurement include greater quantity and quality of information, thereby reducing uncertainty in purchasing activities, as well as faster processing in procurement activities [13].

g. Cross-functional commodity teams. According to Rozemeijer et al. [44], cross-functional commodity teams manage supply and purchasing requirements of many business units within a firm by utilizing collaboration from various functional units. Developing purchasing synergy is the primary goal of cross-functional teams. Ellram et al. [12] and Ellram and Edis [11] confirmed the contribution that purchasing teams make toward the overall cost performance of a firm. Sarin and McDermott [46] also showed that cross-functional teams allow for greater innovation and speed in decision making.

h. Early supplier involvement in design/redesign of products. Ellram et al.,[12] and Ellram and Edis [11] considered early supplier involvement an effective communication mechanism during the beginning stages of product development and procurement operations. They suggested that early supplier involvement is important for new product development. Primo and Amundson [44] also suggested there is a significant benefit to product quality from involving the vendor in new product development. Vendors who are intimately involved with companies in early design processes defining product requirements can significantly reduce cost and schedule performance issues by substantially reducing rework or total redesign of components involved with new designs. Kodak found many of these benefits in its early supplier involvement efforts with product design, as well as the benefits of reduced cycle time and quality problems [12].

i. Non-direct materials (MRO purchases) delegated to manufacturing/operations. Maintenance, repair, and operations (MRO) purchases are trending toward being outsourced, resulting in a reduced supplier base and potential cost savings [51]. In a survey distributed to 400 Fortune 500 purchasing groups, 42% responded that their companies had undergone significant changes in their MRO purchasing procedures, resulting in delegation of these procedures to the internal users of the goods/services [6][17].

j. Supply base rationalization (decrease/increase base). Determining the appropriate number of suppliers is the main foundation for supply base rationalization. The extant literature suggests that supply base rationalization enforces effective supplier selection, volume consolidation, and parts bundling, which in turn contribute to cost reduction and quality improvement, as is the case with Rover Motors [9][33][57].

k. Purchased items are classified as strategic or tactical and are purchased by separate teams. Tactical activities are considered to be of lower importance than other purchasing activities. These activities include several processes such as ordering, quoting, and expediting [6]. Tactical purchases are likely to be outsourced and/or automated over the next ten years, with many tactical purchases pushed into large contracts, thereby reducing the number of employees involved in these purchases [6]. In contrast, strategic purchases
represent items of greater importance, with the procurement process focusing on supplier selection, and selection and development of cross-functional teams. Trent [52] asserted that separation between strategic and tactical purchases improves procurement efficiency.

1. Formal supplier development program. Prahinski and Benton [39] defined formal supplier development programs as efforts by purchasing firms to measure and improve service and/or products received from supplying firms. Such programs can contribute to increased supplier and purchaser performance through enhanced communication and knowledge, which results in a significant positive improvement in buyer-supplier relationship [38]. They also discovered that supplier development activities are positively and significantly related to all aspects of manufacturing performance.

Purchasing Strategic Involvement (SI)

Strategic involvement, viewed as the integration of the purchasing function into corporate strategy, has been recognized for its strategic role [23][30][33][51]. Many have even argued that purchasing contributes significantly to corporate performance, and thus, supply chain management and should be a key component for consideration when developing a company’s overall strategy. In support of this idea, Pearson et al. [37] discussed how overall firm performance is influenced by strategic supplier activities, especially in an international setting, pointing to additional reasoning in support of incorporating the purchasing function into corporate strategy. Lawson et al. [30] and Tan [51] found that companies are increasingly incorporating purchasing activities into corporate strategy, and he suggested that more research should be conducted on the specifics of integrating the purchasing function into corporate strategy.

Based on the above literature review defining important purchasing activities, a theoretical model is proposed in Figure 1. We posit that those purchasing activities and the strategic involvement of purchasing have positive impacts on manufacturing competitiveness measures of cost, quality, delivery, and flexibility. The following hypotheses are thus developed.

H1: Purchasing activities (PA) contribute to manufacturing competitiveness (MC)

H2: Purchasing strategic involvement (SI) contributes to manufacturing competitiveness (MC)

The research hypotheses are developed in order to test a purchasing model that, though well-grounded in the literature, has never been examined with a large international dataset. The remainder of this section discusses the need for testing this model, taking into consideration national differences.

National Culture Differences

Global Studies in various management fields have been performed analyzing cultural effects, such as supply chain effectiveness, project management, forecasting, and regulation compliance on supply performance. For instance, Wacker and Sprague [55] considered the role of national cultural differences and the underlying approach in forecasting. Pagell et al. [36] found that national cultural differences significantly influence international operations management behaviors among similar manufacturing plants in the same industry located in different cultures. Flynn and Sladin [14] examined whether or not the Baldrige criteria have relevance in countries with cultural differences. International projects raise additional issues and problems that have to be managed, such as legal/political issues, security, geography, economic status, infrastructure, and culture. Ruamshook et al. [45] suggested that, to maintain and improve a firm’s future competitive advantage under conditions of heightening global competition, firms must develop and enhance management knowledge in order to optimize the strategic values of differing regions and nations of supply. Their findings indicated the existence of country or regional differences pertaining to supplier performance in the supply chain.

Several researchers have used national culture to illustrate and explain differences between countries. Hofstede [18] defined national culture as the collective mental programming of the people in a national context. Through an empirical study examining more than 10,000 managers in over 50 countries, he developed a quantitative classification scheme for measuring differences and similarities between national cultures. He then proposed that attitudes, beliefs, and behaviors could be categorized into five dimensions: individualism -collectivism, masculinity-femininity, power distance, uncertainty avoidance, and long-term orientation (Confucianism). In light of these five dimensions, Hofstede et al. [19] stated that people of a nation have “patterns of thinking, feeling, and acting that differentiate one country from another and continue to be transferred from generation to generation.” Table 1 provides definitions for the five dimensions and the respective indices for different regions. There seem to be significant cultural differences between Asian, USA, and Western European countries, especially regarding long-term orientation (LTO). Specifically, Asian countries receive an average score of 95, while both USA and Western Europe have average scores of 25.

Table 1. Hofstede’s cultural dimension indices
According to Hofstede et al. [19], Long-term orientation (LTO) (Confucianism) refers to the extent to which one has a long- or short-term orientation. Values associated with Long-term orientation are thrift and perseverance; values associated with Short-term orientation are respect for tradition, fulfilling social obligations, and protecting one’s ‘face’. LTO was previously discussed as an influential factor in purchasing activities. For instance, the strategic sourcing process involves planning and organizing long-term purchasing agreements with suppliers, as suggested by Cavinato et al. [7]. They argued that companies operating in cultures with higher future orientations would be more likely to utilize formal strategic sourcing processes. Moreover, Tucker [53] asserted that strategic supplier partnerships allow for sharing of information that can be vital for the success of both organizations involved, especially when crossing international borders. The development and planning involved in these alliances and partnerships could be supported by a country’s future orientation. Barnes [2] suggested that supply base rationalization is supported by a future orientation, where organizations understand the ever-changing environment and make decisions to develop relationships and rationalize their supply base in an attempt to prepare for the future and secure success.

Overall, the extant literature has successfully demonstrated the effects national differences can have on various operations and supply chain decisions. Nonetheless, empirical support for the effect of national differences on purchasing activities is weak and is mostly from case studies or small-scale survey research, with only two-country comparisons (see example, Carr et al., [5]). The issue of national differences and purchasing activities has not yet been properly examined. This study intends to use a large-scale dataset, with samples from multiple countries to further understanding of this issue. In particular, this study adds to the literature by considering the role of national differences across ten countries involving 511 manufacturing plants. Based on the LTO scores, we combined three Asian countries (China, Korea, and Taiwan) into one group, while Australia, the USA, and several Western European countries (Austria, Germany, Italy, Switzerland, and Sweden) were combined into another group. Table 2 summarizes the issues of the two groups of countries. There is a glaring difference in LTO scores between the two groups. The average LTO score for the first group is 93.33, which is significantly higher than that of the second group, 33.29. We posited that national differences, from the long-term orientation standpoint, could potentially influence the choice and, thus, the efficacy of various purchasing activities and strategic involvement. Therefore, the following hypotheses are developed:

### RESEARCH METHOD

#### Data

The data was a subsample of Round IV of the Global Manufacturing Research Group (GMRG) survey effort. The GMRG is a multinational community of researchers studying the improvement of manufacturing practices worldwide (www.gmrg.org), and consists of leading international academic researchers from over twenty countries who developed the GMRG database survey instrument for use around the world. This survey facilitates global comparison of the effectiveness of manufacturing practices [56]. Since 1985, the GMRG has completed four rounds of the worldwide survey, from the most recent of which we obtained our data. The questionnaires were translated and back-translated for all countries by several academics. This study used the 511 samples collected from ten countries to perform necessary analyses for testing the proposed research hypotheses and the purchasing model (Figure 1). More details of the samples can be found in Table 3.

#### Table 3. Sample demographics

<table>
<thead>
<tr>
<th>Number of Plant Employees</th>
<th>Overall (n=511)</th>
<th>Asia (n=210)</th>
<th>W.Europe/USA (n=301)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;20</td>
<td>15.5%</td>
<td>16.2%</td>
<td>14.8%</td>
</tr>
<tr>
<td>20–100</td>
<td>23.2%</td>
<td>23.7%</td>
<td>22.4%</td>
</tr>
<tr>
<td>&gt;100</td>
<td>23.2%</td>
<td>23.7%</td>
<td>22.4%</td>
</tr>
<tr>
<td>&gt;150</td>
<td>10.0%</td>
<td>9.5%</td>
<td>10.6%</td>
</tr>
<tr>
<td>&gt;500</td>
<td>26.1%</td>
<td>26.8%</td>
<td>25.8%</td>
</tr>
<tr>
<td>1000</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

#### Industry

- Electric & Electronic equipment (SIC 36 & 38): 24.3% 15.0% 34.6%
- Primary & fabricated metal (SIC 10 & 33): 27.7% 19.3% 35.9%
- Plastic (SIC 25-27): 32.4% 8.3% 39.8%
- Other (e.g., textile, food, chemicals, etc.): 100.0% 100.0% 100.0%

#### Measurement: constructs of interest

The purchasing activity (PA) scale addresses various activities in which purchasing personnel engage, including procurement, supplier involvement and development. For each purchasing
activity, managers were asked to what extent the activity is implemented (on a scale of 1-7 with 1 being “not used” and 7 being “a great extent”). All the activities are selected from the following literature: Carter et al. [6], Krause et al. [27], Narasimhan and Das [33], Ellram et al. [12] and Petersen et al. [37]. Overall, a high score on this scale indicates the purchasing function is effectively engaged in a large number of these purchasing practices, while a low score indicates a lower level of effectiveness or involvement. The scale for strategic involvement (SI) was adopted from Rozemeijer et al. [44] and Lawson et al. [30]. It measures the levels at which the purchasing function participates in forming strategic plans and receiving support from top management. A low score suggests a low degree of strategic involvement from the purchasing function.

The scales for manufacturing competitiveness (MC) have respondents rate their competitiveness as compared to their major industry competitors [25][29]. We captured the four main dimensions of manufacturing competitiveness: cost, quality, flexibility, and delivery. The scale was created and verified by previous GMRG studies [36][58].

Psychometric Properties

In this study, we used multiple items to present three latent constructs, Purchasing Activity (PA), Strategic Involvement (SI), and Manufacturing Competitiveness (MC). Each latent construct was tested for internal consistency using Cronbach’s alpha and construct reliability. Alpha coefficients were between 0.73 and 0.89, which are above the benchmark of 0.70 suggested by Nunnally [34], and construct reliabilities were between 0.74 and 0.87, which are above 0.60. Overall, the results suggest high internal consistency of measurement indicators and, hence, reliability of each construct is ensured.

Next, convergent validity and discriminant validity were assessed. O’Leary-Kelly and Vokurka [35] suggested that the use of CFA to assess convergent and discriminant validity is more powerful and requires fewer assumptions than the traditional MTMM (multi-trait multi-method) matrix method. In the CFA model, each item was linked to its corresponding construct and the covariances among those constructs were freely estimated. The resulting model fit indices are $\chi^2 (237) = 529.916$, IFI = .944, NFI = .904, CFI = .944, RMSEA = .049, which were better than the threshold values recommended by Hu and Bentler [22]. Moreover, all of the factor loadings are greater than 0.60 and the $t$-values are significantly greater than 2.0. In summary, the convergence of items on the factors they correspond to is well represented.

Discriminant validity is tested by comparing the correlation coefficients between latent constructs with the variance-extracted percentages for each construct [15]. The results indicate the variance-extracted percentages for constructs were higher than the correlation coefficients between latent constructs. The variance inflation factors (VIF) of all latent constructs were below the recommended value of 10, implying the lack of multicollinearity, thus discriminant validity is supported.

STATISTICAL ANALYSIS

For the purposes of this study, two statistical methods were applied. First, multiple-group structural equation modeling (SEM) analysis was performed to test the postulated research hypotheses and the model in Figure 1. Next, we applied regression analysis to examine whether the two country groups differ in their choice and efficacy of purchasing activities and strategic involvement.

SEM Analysis

A series of multi-group SEM analyses were performed, using LISREL 8.70, to examine whether different groups (Group 1: Asia; Group 2: Western Europe/USA) have different path coefficients of the structural model [16]. We also performed another analysis treating Asia, USA and Western Europe as three separate groups. Table 4 summarizes the SEM results; including model fit indices, standardized path coefficients, and significance levels. The results for both SEM analyses, two groups (Asia vs. Western Europe/USA) and three groups (Asia vs. Western Europe vs. USA), are similar. Our discussion is based on the findings from the two-group analysis as presented in Table 4a.

First, for the All-sample group, the fit indices were all found to be within an acceptable range (CFI = 96, NFI = .94, RMSEA = .050), suggesting a good fit between the model-implied covariance matrix and the data. All causal paths are statistically significant at the 0.05 level, supporting H1 and H2. In other words, both purchasing activities and strategic involvement improve all four aspects of manufacturing competitiveness where the impacts on delivery ($\lambda = 4.30^*$; $\lambda = 4.47^*$) and flexibility ($\lambda = 4.09^*$; $\lambda = 4.43^*$) are higher than on cost ($\lambda = 1.77^*$; $\lambda = 2.04^*$) and quality ($\lambda = 2.04^*$; $\lambda = 2.24^*$).

Table 4. SEM results

<table>
<thead>
<tr>
<th>Structural path</th>
<th>Path coefficients (Standardized)</th>
<th>$R^2$ (Adj)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA-Cost</td>
<td>1.77*</td>
<td>0.10</td>
</tr>
<tr>
<td>PA-Quality</td>
<td>2.04*</td>
<td>0.12</td>
</tr>
<tr>
<td>PA-Delivery</td>
<td>3.04*</td>
<td>0.17</td>
</tr>
<tr>
<td>PA-Flexibility</td>
<td>4.36*</td>
<td>0.17</td>
</tr>
<tr>
<td>SC-Cost</td>
<td>2.04*</td>
<td>0.10</td>
</tr>
<tr>
<td>SC-Quality</td>
<td>2.34*</td>
<td>0.14</td>
</tr>
<tr>
<td>SC-Delivery</td>
<td>4.35*</td>
<td>0.17</td>
</tr>
<tr>
<td>SW-Flexibility</td>
<td>4.45*</td>
<td>0.17</td>
</tr>
<tr>
<td>$R^2$ (Adj)</td>
<td>3.216.8, RMSEA = .050, NFI = .94, CFI = .96</td>
<td>0.32</td>
</tr>
</tbody>
</table>

The results also suggest the moderating effects of national culture on the causal model since two groups display different path coefficients of the structure model. As shown in Table 5a,
three causal paths are moderated by the variable of culture (i.e., PA \rightarrow Cost, PA \rightarrow Quality; SI \rightarrow Cost). According to the estimated path coefficients, the impact of purchasing activities on cost and quality for the Asia group is significantly different from that of the Western Europe/USA group (Δχ² = 42.52** (Cost); Δχ² = 21.62* (Quality)). Meanwhile, the effect of SI on Cost is also significantly different between the two groups (Δχ² = 50.56*). The results suggest that the strategy of improving cost and quality performance by performing purchasing activities works effectively for the Western Europe and USA group but not so for the Asia group. On the other hand, the Asian samples appear to benefit more from purchasing strategic involvement than the Western Europe/USA samples regarding cost performance (λ = 1.64* vs. λ = 1.09*).

For the second SEM analysis (Asia vs. Western Europe vs. USA), similar results are found (Table 4b). Namely, the impact of purchasing activities on cost and quality for Group #1 are significantly different from Groups #2 and #3. In the meantime, the path coefficients for the USA group and the Western Europe group are not significantly different. While more studies must be performed to generalize the findings, our results raise a valid proposition that purchasing activities and strategic involvement adopted by different culture groups have potentially different impacts on manufacturing competitiveness, especially with regards to cost performance. Our findings in Table 4 suggest that Long-term orientation is a more plausible indicator than geographical location to define country groups and predict the effects of purchasing activities and strategic involvement.

In summary, the SEM results suggest that the relationships among purchasing activities, strategic involvement, and manufacturing competitiveness are not always consistent between the two country groups. Therefore, H3 is supported. Purchasing activity and strategic involvement in the Asia group do not seem to contribute to manufacturing competitiveness in the same manner as is seen in the Western Europe/USA group. In order to gain a deeper understanding of the emphasis and efficacy of particular purchasing activities, we decided to perform further analyses at the individual purchasing activities level.

**Regression Analysis**

Table 5 displays the descriptive statistics for purchasing activities, strategic involvement, and competitive goal performance. In general, with a few exceptions, countries in Asia receive higher ratings for their efforts in implementing purchasing activities and purchasing strategic involvement. Meanwhile, no statistically significant difference between Asia and Western Europe/USA is found regarding the four aspects of competitiveness.

Four regression analyses were performed next to examine the effects of individual purchasing activities and strategic involvement on four competitiveness goals. The results of the regression analyses (Table 6) reveal that many purchasing activities contribute to firm performance, but not all activities in both groups similarly or significantly contribute to all four competitiveness goals. More importantly, the contribution of individual purchasing activities and strategic involvement varies between Asia and Western Europe/USA. While strategic involvement influences cost performance in the Asian group, this factor appears to be more influential in Group #2 on quality, delivery and flexibility performance. For the Asia group, only five out of ten purchasing activities contribute to competitiveness. In contrast, for the Western Europe/USA group, eight out of ten activities have significant effects on manufacturing competitiveness. Only four particular activities (reverse auction, cross-functional team, supply base rationalization, and formal supplier development) are beneficial to both groups. Each country group has a different bundle of purchasing activities that it could implement to enhance performance.

### Table 5. Regression analysis (1)

<table>
<thead>
<tr>
<th>Group 1 (n=210)</th>
<th>Group 2 (n=219)</th>
<th>Group 3 (n=223)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA</td>
<td>SI</td>
<td>PA</td>
</tr>
<tr>
<td>---</td>
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</tbody>
</table>

Overall, the results in Tables 5 and 6 indicate that the emphasis and efficacy of purchasing activities and strategic involvement between these two groups are substantially different, thus supporting H3a and H3b at the item level.

**DISCUSSION**

**Efficacy of PA and SI**

Since most purchasing and supply chain management theories were developed based on western culture and data, it is important to verify whether those theories are universal [20][21][36]. Our statistical findings suggest that there are differences between the two country groups regarding their emphasis and efficacy of purchasing activities and strategic...
involvement. The SEM results reveal that the proposed purchasing model, which is well grounded from the purchasing literature, does not receive the same support from the Asian samples despite being verified by the Western Europe/USA data. Three out of eight causal paths were found to be significantly different between the two country groups (Table 4). Several Operations Management (OM) studies previously cautioned about the application of theories developed in North American and European countries to other parts of the world [36][59]. This study validates and reinforces that message.

Another interesting observation from the SEM results is that the strength of path coefficients associated with purchasing activities appears to be consistently weaker in Group #1 (Table 4a, b). On the other hand, the influences of strategic involvement are consistently stronger in Group #1. This finding implies that purchasing activities and strategic involvement in Asian countries do not have the profound contribution to manufacturing competitiveness as is seen in Group #2. In other words, Asian firms, with a relatively high long-term orientation, perceive themselves as being more intensively engaged in purchasing activities, but they are not as effective as their Western Europe/USA counterparts regarding the implementation (Tables 5 and 6). Ruamshook et al. (2007) also observed that European countries and the USA have better supply chain management than some of their counterparts in Asia. Clearly, the question appealing to managers is why differences occur, and there may be several possible explanations for differential effectiveness of purchasing activities between the two country groups. For instance, it is likely that the plants in the USA and Western Europe have more advanced IT or more expertise to perform some of those purchasing activities [5].

It is also possible to attribute the differential effectiveness to the use of Hofstede’s culture scale. According to another renowned national culture research project, the GLOBE (Global Leadership and Organizational Behavior Effectiveness) study, cultural dimensions should be assessed from two perspectives, “as is” and “should be” [21]. The first perspective indicates where managers believe their country currently is and the latter represent where they believe their country ideally should be. Therefore, it is likely that Hofstede’s LTO score captures the “should be” aspect but not the “as is.” Based on the GLOBE project, the countries in Group #1 (Asia) generally have higher “should be” scores than those in Group #2 (Western Europe/USA), a finding consistent with the information from Hofstede’s LTO scores. Meanwhile, Group #1 has lower “as is” scores than Group #2. Specifically, the average “as is” score for Group #1 is 3.89, as opposed to 4.15 for Group #2. That means, in practice, that the countries in Group #2 are actually managing their purchasing function more in tune with the long-term perspective (as is), while Group #1 may desire to be more that way (should be) but fail to. In other words, the mere fact that an Asian firm claims to engage in purchasing activities does not mean that those purchasing activities will be well implemented or deliver competitive advantage. It is beyond the scope of this study to investigate and compare Hofstede’s and GLOBE’s culture scales, but our findings definitely suggest an interesting future research topic.

Engagement of PA and SI

In addition to different path coefficients found from the SEM models, our results reveal that sample plants from Asia perceive that their engagement in purchasing activities and strategic involvement was more intense and more aligned with competitive strategy (Table 5). As discussed earlier in the literature review [7][53], at least three purchasing activities have particular long-term implications on manufacturing operations and are likely to be emphasized by countries with high LTO scores. Those three particular activities and the associated LTO scores for both groups are “Formal strategic sourcing process” (4.70 vs. 3.59), “Supply base rationalization” (4.53 vs. 3.60), and “Formal supplier development program” (4.25 vs. 2.78). We decided to examine how much of the difference between the two groups of countries can be accounted for by the cultural dimension Long-term orientation. To do so, we used hierarchical regression with industry and employment entered as controls in the first step and LTO scores entered in the second step. Hierarchical regression was chosen since it provides a clear picture of additional explanatory power created by adding elements of culture to a base model.

Table 7 summarizes the results of hierarchical regression for the three selected purchasing activities: “Formal strategic sourcing process”, “Supply base rationalization”, and “Formal supplier development program”. For all analyses, we consistently obtain increased adjusted R-squared values after adding the cultural dimension LTO to the control model consisting of only plant size and industry. For “Formal supplier development”, the adjusted R² is .046 with size and industry included in the model, and the addition of LTO score increasing the figure to .201, or an increase of .155. For the other two activities, the adjusted R² increases from .029 and .023 to .095 and .087, respectively. It appears that LTO offers significant explanatory power to the choice and engagement of purchasing activities. Again, these three particular purchasing activities are examined since there is support in the literature for their connection to long-term orientation. Future research should review and verify the effects of culture on other activities.

In summary, our findings from both SEM (Table 4) and regression analysis (Tables 5, 6, and 7) offer strong supports for our research proposition that national culture could affect purchasing activities. National differences or national culture are often treated as control variables in OM literature (e.g., [36]). We are working under the belief that while controlling for culture is better than ignoring it, doing so may still conceal
important differences across cultures. Results based on using culture as a control variable may give a false sense of the universality of a theory and/or result. Our findings indicate the significant explanatory power of national culture, validating the need for using national culture to study national differences regarding purchasing and supply chain management decisions.

CONCLUSIONS

Having an understanding of the international cultures involved in purchasing activities is vital to successful operations, but many purchasing managers do not have the necessary understanding of national differences [3][43]. In the past, OM literature often treated national culture as a control variable [36], ignoring the possibility of using culture as a variable to explain and predict differences in purchasing activities across nations. Responding to the call for better understanding of national differences, this study aims at addressing the research question: Do purchasing theories built on samples from mainly Western companies apply in other cultural contexts? Based on the data collected from ten countries or two distinct cultural groups, we tested a purchasing model that is well-grounded in the literature. Our results suggest that the intensity and efficacy of purchasing activities and strategic involvement vary between the two country groups, Asia and Western Europe/USA. The Western Europe/USA samples adequately fit the purchasing model in Figure 1, but the Asian samples do not. At the item level, we find a common set of purchasing activities contributing to manufacturing competitiveness regardless of national differences. Yet we also find substantial evidence of culturally specific selections of activities. Manufacturing competitiveness is achieved by implementing different bundles of purchasing activities adopted by manufacturing plants from different cultures. In short, the findings suggest that national differences matter in implementing purchasing activities. Previously built purchasing theories and models may not be universal and more studies must be done to examine their applicability. While globalization becomes more widespread, the differences between national cultures must be part of research and theory development regarding supply chains. This study represents a first attempt at using national culture to explain differences in purchasing activities and strategic involvement. To successfully manage an international supply chain, it takes more than knowing that purchasing activities are implemented differently in different countries. While our results clearly suggest the influence of a particular cultural dimension, Long-term orientation, companies must realize what makes purchasing management different in various countries. Specifically, future studies should continue to investigate what dimensions of national culture influence operations decisions and to what extent as well as how that influence occurs. In particular, OM research needs to move beyond macro-level theory that focuses on whether culture matters to the more micro-level question focusing on how culture matters. Such an understanding will better prepare multi-national companies to more effectively manage the global supply chain.

Finally, this study adopted Hofstede’s culture scale to examine the effects of national culture on purchasing activities and decisions. We were able to connect long-term orientation scores with the emphasis firms in different countries place on their purchasing activities and strategic involvement. Nonetheless, Hofstede’s culture score failed to predict the efficacy of purchasing activities and strategic involvement. Future OM research should examine and compare alternative culture scales (e.g., the GLOBE study) regarding their pros and cons for assessing various aspects of purchasing and supply chain decisions. A reliable scale that could accurately capture various cultural dimensions would be beneficial to multinational firms.

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TIME BASED COSTING FOR LEADTIME MANAGEMENT IN MULTI-PRODUCT LINES

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ABSTRACT

Lead time shortening activities are important for manufacturing firms. However, it is difficult to evaluate the effects of such activities on cost reduction by traditional costing methods. To solve this problem, a time based costing method is proposed. In addition, capital expenses are added to the cost of a product because usually the equipment investment costs of this kind of manufacturing firms are relatively high. By using the proposal, the cost of each production process of a product can be evaluated with a high accuracy. At the same time, the effect on reducing cost by lead time shortening activities can be evaluated as well.

Keywords: Time based costing, equipment depreciation, lead time reduction.

Introduction

Lead time shortening activities are important for the manufacturing firms whose equipment investment costs are high. This is because high equipment investment costs mean high machine depreciation expense. The longer the lead time of a product is, the higher the cost will be. Special examples include the firms of semiconductors and LCD panels.

By time monitoring, the time being spent in each workstation of a product can be clarified, so that the workstation whose lead time is the longest can be focused on. However, since the relationship between lead time and product cost was not clarified, effects on cost reduction by lead time shortening activities were hard to evaluate.

Traditional costing methods usually focus on the input (e.g., material, labor and overhead expenses, etc.) and the output (e.g., volume of each product) of the relevant period to calculate a product’s cost.

The direct expenses (e.g., materials, resource expenses, etc.) can be simply allocated to a specific product by considering its material requirement and processing time of resources. In addition, the indirect expenses (e.g., equipment downtime expense, financing costs of equipment purchase, etc.) of the whole shop are collected and then allocated to each kind of product by only taking their quantities [1] into consideration. Since there is also a large number of work in-process (WIP) at each line, the accuracy of the traditional indirect expense allocation method is low. This method was widely used by most single-product lines in which the ratio of direct expenses is relatively high.

However, production type is changing from single-product with large lot size to multiple-product with small lot size. Moreover, the ratio of indirect expense has been increased largely. By using the traditional costing method, the difference in cost among product types cannot be clarified, because the indirect expenses have become the majority of the total costs and were equally allocated to each kind of products. Since operations and equipments required for the products differ largely among product types, the traditional costing approach is not suitable to the current multi-product lines, and new costing methods need to be developed for each product type by considering their different production processes.

In order to calculate a product’s cost in a higher accuracy than the traditional accounting system, activity based costing became popular from the early 1990’s [2]. Activity of each resource is focused on in this method, so that the indirect cost spent on each product can be calculated clearly. However, the weak point of this method is that the costs of idle resources were ignored. In the target lines, equipments investments are high so that idle time of a machine is undesirable and the loss should be evaluated and added to the cost of a product.

On the other hand, some researchers such as Tanaka [3] and Fujimoto [4] proposed a costing method for manufacturing firms by taking capital expense into consideration. This is because usually a manufacturing firm needs to collect funds from outside in order to buy the necessary materials and equipments. However, their method did not consider the expenses incurred by operations.

In order to solve the problems in multi-product lines, a new costing approach is proposed in this paper. The first aim of the proposal is to clarify the relationship between lead time and product costs, so that any improvement plans on lead time reducing can be evaluated by the cost measurement.

The second aim of the proposal is to increase the accuracy of product costing. To achieve this goal, costing methods for direct and indirect expenses need to be reconsidered.

For direct expense, real processing time, instead of standard processing time, is proposed to be used. In the target multi-product lines, necessary operations for completing a product varies among products and a portion of the operations are processed by operators. This means processing time differs among operators according to their different work experiences. The traditional costing method can use the standard time because there were only lines of single-model with a large lot size, and each operator only need to process a limited set of operations so that they can process the operations in standard time limitations. However, in the target lines, both the product mix and the operators change.
frequently, in which only a few operators remain who have enough work experiences and can process operations in standard time limitations. Therefore, in order to increase the costing accuracy, this paper uses real processing time at each workstation to calculate a product’s direct expense.

For the indirect expense, its weight increase largely in the target lines. Also, this expense is traditionally allocated to products only considering the quantity of each product. Thus, the difference in cost among products trends to be difficult to be distinguished. However, in the multi-product lines, the cost difference does need to be clarified. Therefore, this paper propose to evaluate some items of the traditional indirect expenses as direct expenses so that expenses spent on each product can be distinguished.

As a summary, the details of the idea are 1) time loss (resources’ idle time) is evaluated and counted to be direct expense, 2) the expenses spent on changeover and maintenance, which were indirect expenses, are counted and allocated to the relative products.

Therefore, the proposal contains the following three novel characteristics:

(1) It is a time based costing method for a product. Lead time of each product is focused on, and cost of each time interval is accumulated. Thus, cost can be even allocated to a work-in-process;
(2) cost for machine idle time can be calculated and allocated to a relative product as a direct expense;
(3) capital expenses are added to the cost of each product as a direct expense.

Since a set of processes is required for completing a product, this paper focuses on how to calculate the cost of a product at each process. For simplify, each process is supposed to be conducted by only one machine in one workstation with the support of one operator. To accomplish a product, a set of processes are required (e.g., as shown in Figure 1). Depending on the capability of machines, components of products will be processed at a workstation by single unit (e.g., in Figure 1, Process b) or, batch unit (e.g., in Figure 1, Process a, c).

![Figure1. Processes required for accomplishing a product](image)

**Necessary costing items for lead time management in a workstation**

Besides material expenses, there are two types of costs that occur at a workstation. One is resource costs, which includes labor cost and cost related to equipments at that station. The other cost is capital cost.

Resource costs occur when 1) a product is being processed and 2) set up (set off) or maintenance tasks are conducted at that workstation.

Capital cost of a product in a workstation depends on the time that the product occupies the workstation.

By using the idea of capital expense, waiting time of a product (from the viewpoint of a machine, idle time) in a workstation can be evaluated with the cost measurement.

Therefore, this paper proposes to evaluate the cost of producing a product with both the consideration of lead time and capital expense.

In the following sections, firstly, lead time is split into detailed time interval which includes processing time, etc. Then, costing for each kind of time interval is separately calculated and accumulated.

Since huge equipment investments and large operating capital are needed in the target lines, for each kind of time interval, a capital expense is appended. Finally, experimental evaluations of the proposal are conducted.

**Breakdown of lead time**

To accomplish a product in the multiple product lines, a product (strictly, a work piece or work-in-progress) will be processed by a set of sequential workstations. In order to clarify the details of lead time at each workstation, necessary operations for a work-piece are focused on. Considering the purpose of an operation, the following items can be listed up:

(i) Set up: set a work piece (or a set of work pieces) to a machine or a work space so that the machine or the allocated operator can process it;
(ii) Processing: a process to change a work piece’s sharp, value, or characters;
(iii) Set off: remove the processed work piece from a machine or the work place so that other work pieces can be processed there;
(iv) Transportation: transport the work piece (or a set of work pieces) to the next workstation;
(v) Prepare for transportation: prepare the necessary materials from the warehouse, or set the work
piece(s) to a vehicle.

In the experiments, 106 case studies on manufacturing firms are investigated, and 84 operation examples are confirmed. Table 1 shows the result of the investigation.

<table>
<thead>
<tr>
<th>Operation Type</th>
<th>Number of examples</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td>32</td>
<td>Set up the work piece to the lathe</td>
</tr>
<tr>
<td>ii</td>
<td>24</td>
<td>Cutting, turning, milling, etc.</td>
</tr>
<tr>
<td>iii</td>
<td>17</td>
<td>Set off the work piece from the milling machine</td>
</tr>
<tr>
<td>iv</td>
<td>9</td>
<td>Transport the work pieces by vehicle from one workstation to the next one</td>
</tr>
<tr>
<td>v</td>
<td>2</td>
<td>Prepare the materials for the line</td>
</tr>
</tbody>
</table>

Table 1. Confirmation on operation types

Referring Table 1 and considering the time loss (idle time) which may occur in a workstation, lead time of a product at a workstation consists of processing time, set up (set off) time, waiting time and transportation time.

Before starting (or after finishing) an operation, the work piece of a product is set up to (or set off from) the machine by an operator. The main operation is executed by the equipment (machine) there.

A work piece has to wait for its turn since multi products are processed in the same machine. Also, it has to wait if the machine is broken down or under maintenance.

In addition, since work pieces are transported between the adjacent workstations, transportation time occurs among workstations.

Thus, in this paper, lead time of a product in a workstation can be divided as follows (Figure 2):

![Figure 2. Illustration of lead time in a workstation](image)

**Figure 2. Illustration of lead time in a workstation**

- (1) Time waiting for process (waiting time),
- (2) Setup time,
- (3) Processing time,
- (4) Set off time,
- (5) Time waiting for transportation or changeover etc. (waiting time), and
- (6) Transportation time.

**Cost of processing**

A product is processed by a machine at each workstation in the target lines. Here, the equipment depreciation expense is counted as the cost for the period of processing. Therefore, processing cost $C_{pro}$ at workstation $i$ can be calculated by Equation (1), where $DE_i$ is the unit equipment depreciation expense (per hour) of the machine and $opt_i$ is the processing time required in workstation $i$.

$$C_{pro_i} = DE_i * opt_i \quad (1)$$

**Cost of set up (set off)**

Set up and set off are conducted manually. Considering machine is occupied during this period, both labor cost and equipment depreciation expense are counted.

$$C_{setup_i} = (LE_i + DE_i) * upt \quad (2)$$

$$C_{setoff_i} = (LE_i + DE_i) * off \quad (3)$$

$C_{setup_i}$, $C_{setoff_i}$, and $LE_i$ express set up, set off cost and unit labor cost at workstation $i$, respectively. $upt_i$ and $off_i$ express the time required for set up and set off at that workstation, respectively.

**Cost of waiting**

Waiting time occurs when a work piece of a product is transported to a workstation but other product’s work is still under processing at that machine. It also happens when the product has been processed and is waiting for transportation resource’s arrival, or when the machine is under maintenance or broken down.

By using the traditional costing methods, cost loss of this time period cannot be allocated to a specific product. However, from the viewpoint of lead time management, this time loss is large and its impact on product cost does need to be taken into consideration.

To solve this problem, for the waiting time after maintenance, this paper proposes to re-evaluate depreciation expense of the machine. Total cost spent on maintenance $Cm_i$ is calculated which includes labor or outsourcing expenses. Then, this expense is allocated to the machine for the remaining depreciation period $m$ by Equation (4) as illustrated in Figure 3.

$$DE_i' = DE_i + Cm_i / m \quad (4)$$

**Figure 3. Depreciation expense re-evaluation**

Therefore, cost of waiting time spent in a workstation $C_{wait_i}$ can be calculated by Equation (5). Note that waiting time

$$C_{wait_i} = DE_i' \times \text{waiting time} \quad (5)$$

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needs to be divided by considering the maintenance period because \( DE \) will be re-evaluated if the maintenance is conducted. Therefore \( wt_i \) and \( wt'_i \) are used to express the waiting time spent in workstation \( i \) before and after maintenance.

\[
C_{wait_i} = DE_i \ast wt_i + DE'_i \ast wt'_i
\]  
(5)

**Cost of transportation**

Transportations among workstations are conducted by workers with the transportation equipments. Since transportation equipments are relatively cheap, cost of transportation of a product from workstation to the next one (Trans.) is calculated by only considering its labor cost, as concluded by Equation (6). Here, \( transt_i \) is the transportation time from workstation \( i \) to the next one.

\[
transt_i = LE_i \ast transt_i
\]  
(6)

**Additional cost for machine downtime and capital costs**

Costing of each kind of time interval for a product in a workstation has been described above. However, machine downtime also occurs when there are no work pieces at that workstation. This kind of machine downtime implies work load of each workstation of a line is not balanced, or, product switch is not smoothly conducted. By using the traditional costing method, equipment depreciation expenses during this time period cannot be directly allocated to any product. To solve this problem, a cost allocation method is proposed for evaluating this kind of loss.

Whenever machine downtime occurs, WIP of each product in the line during that period will be counted. Equipment depreciation expenses during that period \( C_{downime} \) are averagely allocated to those products. For example, in Figure 4, suppose the line is consisted of 3 processes. Since Machine \( b \) is not running, the equipment depreciation expense during the idle time will be allocated the 10 work pieces which remain in the line during that period.

![Figure 4. Target work pieces of the additional cost allocation](image)

On the other hand, capital costs are added to each type of time interval. The details will be described in the next section.

**Total cost of a product**

In summary, the total cost of a product is calculated by considering its lead time, capital expense at each workstation, and machine downtime losses. Figure 5 shows the image of its cost accumulation in a workstation.

![Figure 5. Cost accumulation at a workstation](image)

**Cost (Yen)**

At time point \( t_0 \), only cost of material \( C_0 \) is counted. Then, at time point \( t_i \), since the work piece has waited for its process turn, cost of waiting \( C_{wait'_i} \) from time point \( t_0 \) to \( t_i \), and the capital expense for \( C_0 \) during this time period is added by Equation (7). Here, \( r \) is the unit interest rate of liability.

\[
C_i = C_0 + C_{wait'_i} + C_0 \ast (t_i - t_0) \ast r
\]  
(7)

In the same way, cost at time point \( t_2, t_3, t_4, t_5 \) and \( t_6 \) can be calculated by Equation (8) to (12), respectively. Here, \( C_{wait''_i} \) is the waiting cost time from \( t_4 \) to \( t_5 \).

\[
C_2 = C_i + C_{setup} + C_1 \ast (t_2 - t_1) \ast r
\]  
(8)

\[
C_3 = C_2 + C_{pro} + C_2 \ast (t_3 - t_2) \ast r
\]  
(9)

\[
C_4 = C_3 + C_{setup} + C_3 \ast (t_4 - t_3) \ast r
\]  
(10)

\[
C_5 = C_4 + C_{wait''_i} + C_4 \ast (t_5 - t_4) \ast r
\]  
(11)

\[
C_6 = C_5 + C_{trans} + C_5 \ast (t_6 - t_5) \ast r
\]  
(12)

Finally, the total cost of a product can be calculated by adding its cost at each workstation and the cost of machine downtime (if it occurs).

### Preparation for the evaluation

The costing method is considered to be used in those lines where main tasks are automatically processed by machines expect set up (set off) tasks. As a precondition, data monitoring of a machine need to be executed in those lines, so that each kind of time interval can be mastered. With the cooperation of a motor production firm, a line is investigated, in which iron core motor is produced. Here, the following four processes (Figure 6.) are focused on, in which lead time is expected to be shortened.

Process I : Iron core pressing
Process II : Shaft pressing
Process III : Insulation coating
Process IV : Commutator pressing

The other preconditions of the target line are:
(i) There are 3 product types (A, B, C) in the line,
(ii) lot size of each product type are 10,
(iii) products are produced in A, B, C cycle, and
the line can produce 600 products a day.

Processing time of each product at each workstation, set up (set off), changeover time, and transportation time are set in advance. All the time are considered to follow a normal distribution. Also maintenance interval is set in advance. Machine break down occurs in a random and unexpected way. Time spent on this kind of repair is also set with a normal distribution.

Test data using in the numerical experiments are created by referring the investigation result of the motor line and some technical manufacturing reports and patents.

In the traditional costing method [1], the equipment depreciation expenses and labor costs are counted as the direct expenses of a product considering how long the equipment and operator has been occupied by that product. Besides, the material expense of producing that product is also counted as the direct expense. Other expenses are collected together and equally allocated to all the products that have been produced during that period as the indirect expenses, which include capital costs, equipment depreciation expenses during machine down time.

**Effect on product cost calculation**

In the numerical experiments, each product type is supposed to be produced 200 units a day. Here, the average cost of each product type by using the proposed time based costing method is compared with the cost obtained by the traditional method.

Taking the cost of product A as the reference, Figure 7 shows the cost ratio of each product type. It is clarified that there is almost no difference in both indirect and direct expenses among the three product types by using the traditional costing method.

However, by using the proposed costing method, the differences in cost among product types become clear (Figure 8). In this example, total cost of product A is clarified to be the largest one. Therefore, product pricing can be set with high accuracy by using the proposal. Moreover, since direct cost of product A is clarified to be the largest one among the three product types, it is easy to choose the target product for cost reduction by the proposal comparing with the traditional costing method.
Effect on lead time and cost reduction

Lead time shortening is considered as one of the improvement approaches for cost reduction. In order to shorten lead time of a product, usually, lead time of each process is investigated and the process with the longest lead time will be set as the target for improvement. However, as it is mentioned in the Introduction section, since the relationship between lead time and cost is not clarified, the traditional approach is not effective on reducing cost.

For example, Figure 9 shows one test result of both lead time and cost for the target four processes of product A. Here, average lead time and cost of the 200 products is used for comparison.

![Figure 9. Lead time and cost of each process](image)

Traditionally, Process III will be focused on for improvement since its lead time is the longest. However, by using the proposal, Process I is set as the target since its cost is the highest.

Thus, two improvement activities can be considered. One is to reduce lead time of Process III by shortening 20 Sec. of its transportation time. The other is to reduce 20 Sec. of processing time in Process I. Here, for simplify, the costs for improvement at each process are supposed to be equal.

Figure 10 and Table 2 show the results of the improvements. The number in the parentheses of Figure 9 shows the workstation number in where lead time reduction activity is conducted.

![Figure 10. Effects on cost reduction by different improvement activities](image)

It is obvious that the proposal can reduce more product cost compared with the traditional method.

Conclusion

A time based costing method for multiple product lines is proposed. By using the proposed approach, cost of each process of a product can be evaluated, so that difference in cost among products can be clarified. Moreover, the relationship between lead time and cost is also clarified in the present paper. By using the proposal, lead time improvement can be conducted efficiently to reduce a product’s cost.

As future directions, more investigations of the target industry can be conducted in order to verify the effects of the proposal in those firms.

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AN NOTE ON SENSITIVITY ANALYSIS FOR EOQ

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ABSTRACT

This study develops an analytical approach of sensitivity analysis for traditional economic order quantity (EOQ). We define an optimal function in which the parameters are treated as variables. The graph of the optimal solution is provided to understand the sensitivity. The gradient is treated as a direction for finding out the optimal solution.

Keywords: Economic order quantity (EOQ), Sensitivity analysis, Gradient

INTRODUCTION

Researches of inventory problem are always summarized by sensitivity analysis ([12]; [10]; [5]; [11]; [8]; [4]). The traditional methodology to investigate the impact of parameters is done by evaluating the target value based on different parameters. Although the performance of traditional methodology is good enough, however, its graphs precision is limited. This is mainly caused by its inability to express the discrete property completely. Ray and Sahu [9] provided the details of sensitivity analysis factors in productivity measurement for multi-product manufacturing firms. Borgonovo and Peccati [2] applying Sobol’ function and variance decomposition method for determining the most influential parameters on the model output. Borgonovo [3] introduced a new method of defining sensitivity measurement that do not rest on differentiability for sensitivity analysis of model output in the presence of finite changes in one or more of the exogenous variables.

Lee and Olson presented a nonlinear goal programming algorithm based on the gradient method, utilizing an optimal step length for chance constrained goal programming models. Arsham [1] developed a full gradient method which consists of three phases: initialization, push and final iteration phase. The initialization phase provided initial tableau which may not have a full set of basis. The push phase used a full gradient vector of the objective function to obtain a feasible vertex. The final iteration phase used a series of pivotal steps using sub-gradient, which leads to an optimal solution. At each iteration, the sub-gradient provides the desired direction of motion within the feasible region.

In this study, sensitivity analysis with continuous domain based on the traditional economic order quantity (EOQ) model is considered.

ASSUMPTIONS AND NOTATION

For convenience, the same assumptions for traditional economic order quantity model are used:

The following notations are used:

\[ D \] demand rate per year
\[ S \] ordering cost per replenishment cycle
\[ H \] inventory holding cost per item per year
* superscript representing optimal value
\[ TC \] total cost per cycle

ANALYSIS OF THE MODEL

This study is based on the traditional economic order quantity (EOQ) model. Assuming the annual demand, \( D \), the ordering cost per replenishment cycle, \( S \) and the inventory holding cost per item per year, \( H \), the optimum operating inventory strategy is obtained by trading off the total ordering cost per unit time and the inventory holding cost per unit time so that the sum will be a minimum. Define \( TC(Q) \) as the sum of ordering cost per unit time and holding cost per unit time when the order quantity is \( Q \). One has

\[ TC(Q) = \frac{D}{Q} S + \frac{Q}{2} H. \] (1)

The well-known economic order quantity, \( Q^* \), is

\[ Q^* = \sqrt{\frac{2DS}{H}}. \] (2)

Then

\[ TC(Q^*) = \sqrt{2DSH}. \] (3)

Define

\[ TCS(D, S, H) = \sqrt{2DSH}. \] (4)

One has

\[ \frac{\partial}{\partial D} TCS(D, S, H) = \frac{SH}{\sqrt{2D}} \] (5)

\[ \frac{\partial}{\partial S} TCS(D, S, H) = \frac{DH}{\sqrt{2S}} \] (6)
The minimum value of the directional derivative $D_{v_1} TCS(D_0, S_H)$ occurs when the direction is

$$v_1 = \frac{-\Delta_1}{|\Delta_1|} = \left( \frac{-H_0}{\sqrt{H_0^2 + S_0^2}}, \frac{-S_0}{\sqrt{H_0^2 + S_0^2}} \right).$$

That means the value of $TCS(D_0, S_H)$ ($TC(Q^*)$ as well) decreases most rapidly at the point $p_1$ along the direction $v_1$.

**Cases II: When $S$ is fixed (Sensitivity analysis for $D$ and $H$)**

In this case, let $S = S_0$

$$\frac{\partial}{\partial S} TCS(D_0, S, H) = \frac{S_0 H}{2D}.$$ \hspace{1cm} (16)

$$\frac{\partial}{\partial H} TCS(D_0, S, H) = \frac{D S_0}{2H}.$$ \hspace{1cm} (17)

Then the gradient, $\Delta_1$, of $TCS$ at point $p_2 = (D_0, H_0)$ is

$$\Delta_1 = \left( \frac{D_0 H_0}{2S_0}, \frac{D_0 S_0}{2H_0} \right).$$ \hspace{1cm} (18)

The length of $\Delta_1$ is

$$|\Delta_1| = \left[ \left( \frac{D_0 H_0}{2S_0} \right)^2 + \left( \frac{D_0 S_0}{2H_0} \right)^2 \right]^{1/2}.$$ \hspace{1cm} (19)

The minimum value of the directional derivative $D_{v_2} TCS(D_0, S_H)$ occurs when the direction is

$$v_2 = \frac{-\Delta_2}{|\Delta_2|} = \left( \frac{-H_0}{\sqrt{H_0^2 + D_0^2}}, \frac{-D_0}{\sqrt{H_0^2 + D_0^2}} \right).$$ \hspace{1cm} (20)

That means the value of $TCS(D_0, S_H)$ ($TC(Q^*)$ as well) decreases most rapidly at the point $p_2$ along the direction $v_2$.

**Cases III: When $H$ is fixed (Sensitivity analysis for $D$ and $S$)**

In this case, let $H = H_0$

$$\frac{\partial}{\partial D} TCS(D, S, H) = \sqrt{\frac{DS}{2H}}.$$ \hspace{1cm} (7)

Then the gradient, $\Delta_0$, of $TCS$ at point $p_0 = (D_0, S_0, H_0)$ is

$$\Delta_0 = \left( \frac{S_0 H_0}{2D_0}, \frac{D_0 H_0}{2S_0}, \frac{D_0 S_0}{2H_0} \right).$$ \hspace{1cm} (8)

the length of $\Delta_0$ is

$$|\Delta_0| = \left[ \left( \frac{S_0 H_0}{2D_0} \right)^2 + \left( \frac{D_0 H_0}{2S_0} \right)^2 + \left( \frac{D_0 S_0}{2H_0} \right)^2 \right]^{1/2}.$$ \hspace{1cm} (9)

Then the gradient, $\Delta_0$, of $TCS$ at point $p_0$ along the direction $v_0$ decreases most rapidly at the point $p_0$ along the direction $v_0$.

**SPECIAL CASES**

**Cases I: When $D$ is fixed (Sensitivity analysis for $S$ and $H$)**

In this case, let $D = D_0$

$$\frac{\partial}{\partial S} TCS(D_0, S, H) = \frac{D_0 H}{2S}.$$ \hspace{1cm} (11)

$$\frac{\partial}{\partial H} TCS(D_0, S, H) = \frac{D_0 S}{2H}.$$ \hspace{1cm} (12)

Then the gradient, $\Delta_1$, of $TCS$ at point $p_1 = (S_0, H_0)$ is

$$\Delta_1 = \left( \frac{D_0 H_0}{2S_0}, \frac{D_0 S_0}{2H_0} \right).$$ \hspace{1cm} (13)

the length $\Delta_1$ of is

$$|\Delta_1| = \left[ \left( \frac{D_0 H_0}{2S_0} \right)^2 + \left( \frac{D_0 S_0}{2H_0} \right)^2 \right]^{1/2}.$$ \hspace{1cm} (14)

$$= \frac{D_0 H_0^2 + D_0 S_0^2}{2S_0 H_0}. \hspace{1cm} (14)$$

The minimum value of the directional derivative $D_{v_1} TCS(D_0, S_H)$ occurs when the direction is

$$v_1 = \frac{-\Delta_1}{|\Delta_1|} = \left( \frac{-H_0}{\sqrt{H_0^2 + S_0^2}}, \frac{-S_0}{\sqrt{H_0^2 + S_0^2}} \right).$$ \hspace{1cm} (15)

The minimum value of the directional derivative $D_{v_1} TCS(D_0, S_H)$ occurs when the direction is

$$v_1 = \frac{-\Delta_1}{|\Delta_1|} = \left( \frac{-H_0}{\sqrt{H_0^2 + S_0^2}}, \frac{-S_0}{\sqrt{H_0^2 + S_0^2}} \right).$$ \hspace{1cm} (15)
\[ \frac{\partial}{\partial D} TCS(D, S, H_0) = \pm \frac{SH_0}{2D}. \] (21)

\[ \frac{\partial}{\partial H} TCS(D, S, H_0) = \pm \frac{DH_0}{2H}. \] (22)

Then the gradient, \( \Delta_3 \), of \( TCS \) at point \( p_3 = (D_0, S_0) \) is

\[ \Delta_3 = \left( \frac{S_0 H_0}{2D_0}, \frac{D_0 H_0}{2S_0} \right). \]

(23)

The length of \( \Delta_3 \) is

\[ |\Delta_3| = \left( \frac{S_0 H_0}{2D_0} \right)^2 + \left( \frac{D_0 H_0}{2S_0} \right)^2 \]

\[ = \sqrt{\frac{S_0^2 H_0^2 + D_0^2 H_0^2}{4D_0 S_0}}. \]

(24)

The minimum value of the directional derivative \( D_{v_j} TCS(D, S, H_0) \) occurs when the direction is

\[ v_j = \frac{-\Delta_3}{|\Delta_3|} = \left( \frac{-S_0}{\sqrt{S_0^2 + D_0^2}}, \frac{-D_0}{\sqrt{S_0^2 + D_0^2}} \right). \]

(25)

That means the value of \( TCS(D, S, H_0) \) (\( TC(Q^*) \) as well) decreases most rapidly at the point \( p_3 \) along the direction \( v_3 \).

**Cases IV: When \( D \) and \( S \) are fixed (Sensitivity analysis for \( H \))**

In this case, let \( D = D_0, S = S_0 \)

\[ \frac{d}{dH} TCS(D_0, S_0, H) = \pm \frac{D_0 S_0}{2H}. \]

(26)

That means the value of \( TCS(D_0, S_0, H) \) (\( TC(Q^*) \) as well) decreases most rapidly at the point \( H_0 \) along the direction of negative \( H \) axis.

**Cases V: When \( D \) and \( H \) are fixed (Sensitivity analysis for \( S \))**

In this case, let \( D = D_0, H = H_0 \)

\[ \frac{d}{dH} TCS(D_0, S, H_0) = \pm \frac{D_0 H_0}{2S}. \]

(27)

That means the value of \( TCS(D_0, S, H_0) \) (\( TC(Q^*) \) as well) decreases most rapidly at the point \( S_0 \) along the direction of negative \( S \) axis.

**Cases VI: When \( S \) and \( H \) are fixed (Sensitivity analysis for \( D \))**

In this case, let \( S = S_0, H = H_0 \)

\[ \frac{d}{dD} TCS(D, S_0, H_0) = \sqrt{\frac{S_0 H_0}{2D}} > 0. \]

(28)

That means the value of \( TCS(D, S_0, H_0) \) (\( TC(Q^*) \) as well) decreases most rapidly at the point \( D_0 \) along the direction of negative \( D \) axis.

**NUMERICAL EXAMPLES**

To validate the theory, numerical parameters are used:

\( D = 50000 \) units/year, \( S = 200 \) units/year, \( H = $5/\)unit/year, Applying Eq.(2), the EPQ is \( Q^* = 2000 \) units and the minimum cost per year \( TC(Q^*) = $10000 \).

The optimal direction of \( TCS(D, S, H) \) (\( TC(Q^*) \) as well) to find the lowest cost at point \( (D = 50000, S = 1000, H = 5) \) is \( v_0 = (D = -9.997*10^{-5}, S = -0.025, H = -0.997) \).

When \( D = 50000 \) is fixed, the optimal direction of \( TCS(D, S, H) \) to obtain the lowest cost at point \( (S = 1000, H = 5) \) is \( v_1 = (S = -0.025, H = -0.997) \). The shape of \( TCS(D = 50000, S, H) \) on the domain \([100, 300] \times [3, 7]\) is depicted as Figure 1.

![Figure 1. The shape of TCS (D = 50000, S, H) on the domain [100, 300] \times [3, 7].](image)
Hui-Ming Teng, Ping-Hui Hsu, Yufang Chiu & Hui Ming Wee

Figure 2: The shape of $TCS (D = 50000, S, H)$ on the domain $[100, 300] \times [3, 7]$.

When $H = 5$ is fixed, the optimal direction of $TCS(D, S, H)$ to find the lowest cost at point $(D = 50000, S = 10000) = (D = -4 \times 10^{-3}, H = -0.999)$. The shape of $TCS(D, S, H = 5)$ on the domain $[30000, 70000] \times [100, 300]$ is depicted as Fig 3.

Figure 3: The shape of $TCS (D, S, H = 5)$ on the domain $[30000, 70000] \times [100, 300]$.

When $S = 200, H = 5$ are fixed, the shape of $TCS(D, S = 200, H = 5)$ on interval $[30000, 70000]$ is depicted as Fig 4.

Figure 4: The shape of $TCS (D, S = 200, H = 5)$ on interval $[30000, 70000]$.

CONCLUSION

This study develops an alternative approach for parameter sensitivity analysis. The optimal directional derivatives can be a feasible direction for managers. The graph of the parameters function is good tool for understanding the parameters. This study provides a more precise basis of sensitivity analysis.

REFERENCES

ABSTRACT

For an enterprise, no orders no profits. The forecast of order quantity affects the decision of the balance of production capacity. In the field of Industrial Engineering and Management, some traditional time series forecasting technologies such as moving average and exponential smoothing methods are popular and have been used for order forecast. Recently, machine learning methods in the field of Artificial Intelligence (AI) have also been used for prediction, among them including Artificial Neural Network (ANN) and Fuzzy Neural Networks (FNN) approaches. In this study, real mechanic order quantity data are used to compare the forecasting efficiency of the above mentioned four methods. The results indicate that FNN method has better forecast accuracy than the others.

Keywords: moving average, exponential smoothing, ANN, FNN, forecast

INTRODUCTION

To an enterprise, orders are important. Many factories begin their production activities after they receive product orders. If orders come intensively in a short period of time, it causes the paucity of materials, parts, and human powers. In order to deliver the goods in time, laborers have to work overtime, which would incur extra cost in wedges. On the other hand, when production capacities are idle, employees have no work to do, and costs are wasted. Therefore, it is very important to forecast order quantity as accurately as possible.

This study mainly uses the data of the CHTA Heng Industry company as a case study in order to control the balance of the capacity requirements and the order quantity. CHTA Heng Industry company is a hardware company that manufactures heat sink, stator, bracket, isolated cover, outer case for machine, and mechanic faceplate manufactured using Computerized Numerical Control (CNC) punches and press brakes. Four kinds of packaging machines parts for a long term customer comprise of 70% of the company’s income. Actually, this company is the largest company to provide packaging machines parts in Taiwan. However, the product demands are usually unsteady and cause the unnecessary wastes of costs. Therefore, applying forecasting technology to predict the order quantity for CHTA Heng Industry for cost saving is an important issue.

There are some time series forecasting technologies based on moving average [1-2] and exponential smoothing [3-4] methods. These methods consider only previous order quantities to predict further demands without considering other affecting factors. However, factors such as season, price, and economic trend may affect product demands. Although season, trend, and cycle factor can be calculated and adapted from the past data, forecasting errors are large when not enough data are available on hand. In this work, we try to use machine learning methods introduced in artificial intelligence researches to reduce forecasting errors caused by lack of available data, this study includes other affecting factors coupled with applying artificial intelligence methods in order to increase the forecast accuracy for the further order quantities.

More specifically, this study uses CHTA Heng Industry company’s historical data processed by moving average, exponential smoothing, Artificial neural network (ANN), and Fuzzy Neural Networks (FNN) methods to help control the production capacity and make a comparison of these four methods.

In the following sections, we will first provide brief reviews of the four methods used in our study. Then, we describe the data used in our experiments. Next, we present the experimental results and discussion, followed by conclusions and references.

REVIEW

Moving average method

Moving average method averages the data values over a certain period of time of past and uses the average value to forecast the upcoming value. The benefit of this method is that the extreme datum with large difference from general data in the period of time will be offset and smoothed. Therefore, average data or forecast data values are renewed dynamically. When new datum arrives, the old forecast value is removed and the new predicted value is refreshed. The system always keeps the newest forecasting datum. The number of time units of the data affects the variation of the average values. If the length of time period is short, the variation among the average values is large. Otherwise, the variation is small but the prediction is not smart.

Moving average method takes average over all the data in $t$ period of time up until the current data. It could be calculated as:

$$MA_n = \frac{\sum_{i=1}^{n} A_i}{n}$$

where $MA_n$ is the moving average forecast value, $n$ is the
number of period of time, and \( A_t \) is the \( t \)th value.

### Exponential smoothing method

Exponential smoothing method is a kind of moving average methods but needs simple information only. It is easy to calculate and is easy to change data weights, also it needs only small storage space in a computer. When there are many items for forecasting, it is specially suitable for computerized implementations. Exponential smoothing method uses the value of an Alpha Factor to decide the degree of reaction for the previous forecast error. The range of Alpha Factor value is between 0 and 1, where a value in 0.2 to 0.5 is commonly used. It means that the current forecast value shall consider 20\% to 50\% of the previous forecast error. Exponential smoothing can be calculated as:

\[
F_t = F_{t-1} + \alpha(A_{t-1} - F_{t-1})
\]

where \( F_t \) is the forecast value of the \( t \)th period of time, \( F_{t-1} \) is the forecast value of the \((t-1)\)th period of time, \( A_{t-1} \) is the actual value of the \((t-1)\)th period of time, and \( \alpha \) is Alpha Factor, \( 0 \leq \alpha \leq 1 \).

### Artificial neural network

Artificial neural network was introduced in the era of 1940’s inspired by biological neuron networks of human brains, and it introduced a new paradigm parallel and distributed computing [5, 9-17]. It was popularized by a simple family of two-layer neural networks called Perceptron [10, 11, 12], which is capable of learning solutions from training data to linearly separable classification problems. One important and useful feature of Perceptron is the convergence property, which says that if a linearly separable problem is solvable, then the solution can be found by a Perceptron in a finite amount of time [16]. However, for non-linear problems as simple as the XOR problem, they cannot be solved by simple two-layer networks [10]. Multi-layer artificial neural networks with back-propagation learning procedure for solving non-linear problems was introduced by [13-15]. However, in general, the convergence to a solution cannot be guaranteed for multi-layer networks. Another popular ANN was introduced in the form of learning associations from training data [17].

One example of multi-layer neural network is the Fuzzy neural network that will be reviewed in the following section. While applying ANN, we need two sets of data, one is used as training data set, the other is used as checking data set. Training data are used to train ANN in order to increase the forecast accuracy, and checking data are used to check the prediction accuracy.

### Fuzzy neural network

Fuzzy Neural Networks, also known as Neuro-fuzzy systems, are multi-layer neural networks integrated with fuzzy inference systems. ANFIS (Adaptive Network based Fuzzy Inference Systems) is a popular FNN tool proposed by Jang [6]. Given a set of input and output data, ANFIS can construct a fuzzy inference system with membership functions generated by adaptive back-propagation learning.

The basic model of ANFIS is the Sugeno fuzzy model [7, 8]. Let \( x \) and \( y \) be two input variables, let \( z \) be the output variable, and the fuzzy if-then rules are formatted as:

\[
\text{If } x = P \text{ and } y = Q \text{ then } z = f(x, y)
\]

Consider two first-order rules of Sugeno fuzzy model, the if-then rules can be:

Rule A: If \( x = P_1 \) and \( y = Q_1 \), then \( f_1 = m_1 x + n_1 y + c_1 \).

Rule B: If \( x = P_2 \) and \( y = Q_2 \), then \( f_2 = m_2 x + n_2 y + c_2 \)

where \( P_i \) and \( Q_i \) are fuzzy sets, and \( m_i \), \( n_i \) and \( c_i \) are constants for \( i = 1, 2 \). The Sugeno model is shown in Fig. 1(a), and the corresponding ANFIS structure with a five-layer artificial neural network is shown in Fig. 1(b).

The following is a brief description of the five layers in ANFIS. Let the output of the \( i \)-th node of layer \( l \) be \( O_{l,i} \). In Layer 1 of ANFIS,

\[
O_{l,i} = \mu_{M_i}(x) , \quad i = 1, 2, \text{ or } O_{l,i} = \mu_{N_{i-2}}(y), \quad i = 3, 4
\]

where \( \mu_{M_i} \) and \( \mu_{N_{i-2}} \) are arbitrary fuzzy membership functions of any types such as triangular or generalized bell function.

![Fig. 1 (a)](image)

The Sugeno fuzzy mode; (b) The ANFIS structure.

For nodes in Layer 2, the outputs \( W_i \) are the products of the
outputs of Layer 1, and they are used as the weights of Layer 3:

$$O_{2i} = w_i = \mu_{M_i}(x)\mu_{N_j}(y), \ i = 1, 2$$

In Layer 3, the output of every node is normalized as follows:

$$O_{3i} = \overline{w}_i = \frac{w_i}{w_i + w_2}, \ i = 1, 2$$

Next, Layer 4 is the defuzzification layer which adapts node values with the following equation:

$$O_{4i} = \overline{w}_i f_i = \overline{w}_i (m_i x + n_i y + c_j), \text{ for } i = 1, 2$$

where $m_i$, $n_i$, and $c_j$ are parameters of the nodes.

Finally, the fifth layer is to compute the output from all the input signals using the equation:

$$O_{5i} = \sum_i \overline{w}_i f_i = \frac{\sum_i w_i f_i}{\sum_i w_i}, \text{ for } i = 1, 2$$

**Root mean squared error**

In this study, the measurement of errors used to compare the four different forecasting methods is based on the Root Mean Squared Error (RMSE). The RMSE is used to estimate the prediction error, and it is defined as:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} (A_i - F_i)^2}{n}}$$

where $A_i$ is the actual value of the $i^{th}$ period to time, $F_i$ is the forecast value of the $i^{th}$ period to time, and $n$ is the total data number.

**EXPERIMENTAL DATA SETS**

Experiments conducted in this study to compare the forecast efficiency of both time series and machine learning methods are based on data collected from the CHTA Hering Industry company between 1996 to 2007. There are 980 records in total, including four products: TC-002, TC-043, TJ-002-203, and TC-2-20110 which are represented as P1, P2, P3, and P4, respectively.

For the Moving average and the Exponential smoothing methods, monthly order quantities are used. Table 1 shows 11 data points from the monthly order data set.

For the ANN and FNN methods, the information used for training the learning methods and for predicting order quantities is different from time series methods. Each item in the data set consists of input and output attributes. The input attributes include year, month, and price, and the order quantity is the output attribute. Some of this data set is shown in Table 2. Data from 1996 to 2006 are used as training data sets, and data of 2007 is used as checking data.

### Table 1. Part of the data for time serial methods

<table>
<thead>
<tr>
<th>No.</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1652</td>
</tr>
<tr>
<td>2</td>
<td>385</td>
</tr>
<tr>
<td>3</td>
<td>1756</td>
</tr>
<tr>
<td>4</td>
<td>1204</td>
</tr>
<tr>
<td>5</td>
<td>1400</td>
</tr>
<tr>
<td>6</td>
<td>1200</td>
</tr>
<tr>
<td>7</td>
<td>1350</td>
</tr>
<tr>
<td>8</td>
<td>1800</td>
</tr>
<tr>
<td>9</td>
<td>1000</td>
</tr>
<tr>
<td>10</td>
<td>1904</td>
</tr>
<tr>
<td>11</td>
<td>1414</td>
</tr>
</tbody>
</table>

### RESULTS

**Moving average method**

The results of applying moving average method to the experimental data are shown in Table 3. The time series moving average method is applied with three different lengths of period of time $N = 3$, $N = 5$, and $N = 7$. The forecasting results are collected for the four different products P1, P2, P3, and P4. Their RMSE values are as shown in Table 3. For P1, P2, and P4, the RMSE in 7 period of time are better than the others. For P3, their RMSE are almost the same. Therefore, the results indicate that RMSE for 7 period of time is better than the others.

### Table 2. Part of the data for machine learning.

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Price</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>1</td>
<td>180</td>
<td>1652</td>
</tr>
<tr>
<td>2007</td>
<td>2</td>
<td>180</td>
<td>385</td>
</tr>
<tr>
<td>2007</td>
<td>3</td>
<td>180</td>
<td>1756</td>
</tr>
<tr>
<td>2007</td>
<td>4</td>
<td>180</td>
<td>1204</td>
</tr>
<tr>
<td>2007</td>
<td>5</td>
<td>180</td>
<td>1400</td>
</tr>
<tr>
<td>2007</td>
<td>6</td>
<td>190</td>
<td>1200</td>
</tr>
<tr>
<td>2007</td>
<td>7</td>
<td>190</td>
<td>1350</td>
</tr>
<tr>
<td>2007</td>
<td>8</td>
<td>190</td>
<td>1800</td>
</tr>
<tr>
<td>2007</td>
<td>9</td>
<td>190</td>
<td>1000</td>
</tr>
<tr>
<td>2007</td>
<td>10</td>
<td>190</td>
<td>1904</td>
</tr>
<tr>
<td>2007</td>
<td>11</td>
<td>190</td>
<td>1414</td>
</tr>
<tr>
<td>2007</td>
<td>12</td>
<td>190</td>
<td>900</td>
</tr>
</tbody>
</table>

### Table 3. RMSE of moving average method
Exponential smoothing method

Data used for the exponential smoothing method are the same as those used in the moving average method. The Alpha Factor $\alpha$ is set as 0.1, 0.3, 0.5, 0.7 and 0.9 to forecast the order quantities. The RMSE values are listed in Table 4. In the results, when $\alpha = 0.1$, the forecast errors are smallest in P1, P2, and P4. Although $\alpha = 0.3$ has the smallest error in P2, but the error is similar to $\alpha = 0.1$ and $\alpha = 0.5$. In summary, $\alpha = 0.1$ has the better forecast results in exponential smoothing method.

Table 4. RMSE of exponential smoothing method

<table>
<thead>
<tr>
<th>$\alpha$</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>358</td>
<td>236</td>
<td>71</td>
<td>94</td>
</tr>
<tr>
<td>0.3</td>
<td>377</td>
<td>225</td>
<td>72</td>
<td>99</td>
</tr>
<tr>
<td>0.5</td>
<td>405</td>
<td>234</td>
<td>75</td>
<td>105</td>
</tr>
<tr>
<td>0.7</td>
<td>440</td>
<td>249</td>
<td>80</td>
<td>112</td>
</tr>
<tr>
<td>0.9</td>
<td>484</td>
<td>267</td>
<td>88</td>
<td>120</td>
</tr>
</tbody>
</table>

ANN(1)

We use two kinds of data to predict order quantities by the ANN approach. In this subsection, following the different period of time concept in moving average method, we use the previous certain period of time data to forecast newest value by ANN. For example, when N=3, three periods of time data $\{x_1,x_2,x_3\}$ are used as 3 input data to forecast $x_4$ the fourth value. When $\{x_2,x_3,x_4\}$ are used as 3 input data, $x_5$ is the value to be predicted. The RMSE results are shown in Table 5. It is clear that when N=3, RMSE is the smallest.

Table 5. RMSE of ANN(1)

<table>
<thead>
<tr>
<th>N=3</th>
<th>N=5</th>
<th>N=7</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>479</td>
<td>533</td>
</tr>
<tr>
<td>P2</td>
<td>265</td>
<td>280</td>
</tr>
<tr>
<td>P3</td>
<td>103</td>
<td>98</td>
</tr>
<tr>
<td>P4</td>
<td>115</td>
<td>224</td>
</tr>
</tbody>
</table>

ANN(2)

Another way to apply ANN method for prediction is to use more attributes to represent data. In this section, data attributes year, month, and price are used as inputs and quantity is used as output. After training and checking, the RMSE for each product is presented in Table 6.

Table 6. RMSE of ANN(2)

<table>
<thead>
<tr>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
</tr>
</thead>
<tbody>
<tr>
<td>368</td>
<td>221</td>
<td>83</td>
<td>111</td>
</tr>
</tbody>
</table>

In Fig. 2, RMSE of ANN(1) with N=3 is compared with the result of ANN(2). It is clear that ANN(2) is better than ANN(1).

FNN

For the FNN method, the data set used for learning is the same as in ANN(2) with three input attributes and one output attribute. After learning and checking, the RMSE for the four products are shown in Table 7.

Table 7. RMSE of FNN learning

<table>
<thead>
<tr>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
</tr>
</thead>
<tbody>
<tr>
<td>346</td>
<td>170</td>
<td>69</td>
<td>87</td>
</tr>
</tbody>
</table>

In Fig. 3, the RMSE of ANN(2) and FNN methods are compared. For all four products, it is clear that using FNN is better than using ANN(2).

Discussion

The prediction results from our experiments based on five different methods are summarized in Table 8. In the table, the best result for product P1 in moving average method with
N=7 is 376, in exponential smoothing method is 479, in ANN(2) is 368, and in FNN is 346. Therefore, the best forecast method for P1 is FNN.

The bar charts shown in Fig. 4, 5, 6, and 7 provide another look of the comparison of prediction performance on the four products P1, P2, P3, and P4 by using the five different forecasting methods. The figures indicate that FNN is the best forecast method for all the products. Also, results of ANN and FNN are better than the others. It may be that data for ANN and FNN provide more information, three input attributes, to help the system increases prediction accuracy.

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<th>Table 8. Summary results</th>
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<td>ANN(2) (year, month, price)</td>
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CONCLUSIONS

It is very important for a company to balance its production capacity and required orders. However, it is challenging to predict order quantities, since order demanding patterns are unsteady in general. It is clear that production capacity may become insufficient when the quantity of orders jumps up abruptly, and it may lead to extra overtime labor costs, delay of finishing products, or losing customers. On the other hand, when the quantity of orders suddenly decreases, production capacity is wasted. Labors and machines are idle but the company still has to pay salaries and machine costs.

In this study, we compared traditional time series forecasting methods with artificial intelligence machine learning methods by using historical data collected from a real company. The problem faced by the company is a common problem to most of the companies, namely, the quantity of orders is uncertain and with wide variations.

Our experiments was conducted by using the real data collected from four different kinds of products. The results indicate that FNN machine learning method has the best forecasting accuracy for all the products.

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ABSTRACT

A vast amount of government data is available digitally but not in a form useful to the public. Online news entities, in particular Everyblock.com, are beginning to present this data online but not in an up-to-the-minute form and not for mid-size communities like Anchorage. Additionally, there is no doubt that traditional news organizations are concerned about the loss of viewers and circulation. This project attempts to solve these problems and explore the potentials in the emerging field of computational journalism. The Anchorage OpenBlock project has been trying to follow EveryBlock’s footsteps and rationale with a “geographic filter” that provides a “news feed” for users’ neighborhoods.

Keywords: Computational Journalism, OpenBlock, EveryBlock, block news, hyper-local service

INTRODUCTION

In his talk at Hong Kong University Journalism and Media Center in March, 2011, Dr. Nick Diakopoulos defined Computational Journalism as “using computing to facilitate, enable and reinvigorate the practices and processes of journalism, including collecting, organizing, making sense of, communicating and disseminating news information, while upholding the values of journalism such as fairness and accuracy” [1],[2]. He argues that computation (and the related networking, information technology, etc.) is now intertwined with all aspects of journalism, including newsgathering, investigative journalism, verification/fact finding, authoring/printing/publication/broadcasting of news, sharing and distribution of news information, editing and commenting on news, etc [3].

Computation has not only impacted these aspects, but has also thoroughly disrupted journalism’s traditional distribution models. Journalists now have new ways of providing the information citizens need for civic engagement. In other words, the major objective of Computational Journalism is to study the overlapping interests between computation and journalism and to define how both of these elements can help with information gathering and dissemination for and by citizens to achieve an engaged and more actively participating citizenry.

As Diakopoulos mentioned in his talk, “information comes at us faster and faster and the news media have more and more data to deal with. Social media is pumping out terabytes of this every day. We need computers to help us deal with that scale.” We also see that a vast amount of government data is available digitally but not in a form useful to the public. Although the general public still believes that newspapers play a critical role in the democratic process by framing the conversation and encouraging informed debate and decision-making, there is no doubt that traditional news organizations are concerned about the loss of viewers and circulation. And this issue is even more acute when it comes to local news. For example, the largest newspaper in Alaska, the Anchorage Daily News, has lost at least 115 positions company-wide through layoffs and attrition since June 2008 [4],[5],[6]. Newspaper companies have struggled in the age of the Internet, but this disruptive medium also offers opportunities for a new kind of journalism – one that can play the same critical role in the society and do it more efficiently.

With this in mind we began a computational journalism project to collect and present localized public data to users in Anchorage, Alaska. Our effort follows in the footsteps of the 2007 Knight News Challenge winning EveryBlock project.

Our goal is to adapt EveryBlocks’s code and experiment with new ways for users to find local news and public information. This project will be implemented in two phases: the first phase started with the installation of a pilot version - - including mapping and updated news feeds -- customized for our community in Anchorage. The objectives we have set up for this project’s news feeds should be:

a. Automated. We need to use data primarily through automated feeds. Due to limited time available, data collection and presentation need to be accomplished through scripting.

b. Trustworthy. The source of the data must be included in the project site design.

c. Timely. Delayed information will severely limit the usefulness of the project.

d. Scalable. The capacity to add data feeds as they are identified needs to be built into the design of the project.

The second phase of the project will focus on the sustainability of this new form of online news site. This phase will experiment and explore a workable business model, with a sustainable, and even profitable, sit our long term goal. It will proceed after we finish the first phase to get the site up and running. This paper primarily discusses the work accomplished in the first phase. It starts with an introduction section and is followed by the sections on history and background, technology and implementation, conclusion and future study.
**HISTORY and BACKGROUND**

Federal, state, and local government agencies publish vast amount of public data online but much of it is in a form that is difficult for consumers to use. News organizations are starting to explore this space, but they either lack the technological staff in their organization to process the data or else tend to build interactive, Flash-based graphics for a specific story, such as the New York Times’s Broad Unemployment Across the U.S. [8] and Clean Water Act Violations: The Enforcement Record [9]. These data packages are usually difficult and time consuming for news organizations to create. It usually requires three personnel assets to produce this kind of data graphic: expert reporters, data integration expertise and Flash graphic expertise. The New York Times might be the last newspaper in North America that has all three, according to Mindy McAdams at the University of Florida [10].

Some non-traditional journalism sites like the political site FiveThirtyEight [11] and news mapping site EveryBlock [12] have entered this data-driven reporting space but they offer the data of interest to only a small segment of users. EveryBlock.com (figure 1) is a new experiment in online journalism, collecting public data for 16 American major cities and presenting the information for online by neighborhood and zip code. It began with a two-year, $1.1 million grant funded by the Knight Foundation [13] and was acquired by MSNBC.com in August 2009 [14].

The goal of EveryBlock is to collect all of the news and civic goings-on that have happened recently in the user’s block, and make it simple for users to keep track of news in particular areas. They seek to be a geographic filter — a “news feed” for customer’s neighborhood or block [15]. A user need only enter an address, neighborhood or ZIP code in the cities being served, and the site will produce recent public records, news articles and other Web content that’s geographically relevant to the location.

At EveryBlock, they treat freshly updated public records as block-level news. It’s their goal to acquire ongoing feeds of government data and spread the gospel of open data. The two major objectives are to get more datasets for EveryBlock so it can be a better Web site and to convince governments to share that data with everyone, not just the site itself.

In June 2010, the John S. and James L. Knight Foundation announced a plan to expand the EveryBlock project to make it easier for news organizations to use the EveryBlock code [16]. The new software, which is also an open source, is called OpenBlock. The Knight Foundation has awarded nearly $460,000 in this second round of funding. OpenPlans, a New York-based non-profit organization received a $235,000 grant to extend the EveryBlock.com code while the Columbia Daily Tribune and the Boston Globe were awarded with grants to install and test the software. OpenPlans began releasing updates to the Everyblock code in September, 2010 and the chief developers are active on the EveryBlock discussion group (eb_code) on Google Groups [17]. The OpenBlock is a project currently under active development, with a public release planned for Spring 2011.

**TECHNOLOGY and IMPLEMENTATION**

**A. Technologies**

The project requirements in large part dictated the core technology choices. Our EveryBlock Anchorage project is based on the Django Web Framework [18] by following the technologies chosen by EveryBlock (now OpenBlock). Django is an open-source framework developed for the online operation of a newspaper which can be used to create Web applications on tight deadlines. “[Django is] is programming tool that lets you build web sites and uses the Python programming language.” [19]. We chose the Linux operating system Ubuntu (desktop V9.10) for simplicity. This project also requires PostGIS, an open-source spatial database extender for PostgreSQL.

This project adopts a parallel desktop virtual machines approach for its development to insure a clean development environment and allow snapshots to be taken as progress is made or whenever the dependencies and libraries are added and updated.

**B. Implementation Methodology**

To create the EveryBlock Anchorage site requires two separate steps: installing a working instance of the application and loading local data into the application.

1. **Install instance for Anchorage**

The project started to use the EveryBlock open-source code with a clean installation of Ubuntu 9.04 and all updates. In-depth research was needed in addition to the original EveryBlock set-up instructions. With support from help documents for GeoDjango [20], a geospatial extension of Django, we finally got the original framework done. During this process, the eb_code group on Google Groups also provided critical assistance, including installation instructions for the EveryBlock code on Ubuntu 9.10, as well as the steps to load demonstration data for the city of Boston.

The EveryBlock community expanded dramatically in the summer of 2010 with the Knight Foundation’s funding of the OpenBlock project. The Open Block team forked an existing github EveryBlock repository [21] and released an alpha version of their code in September [22]. The OpenBlock repository includes a map component, a Python-based bootstrap file in order to load Boston-area data into the application, as well as the ability to use Django’s GUI administration interface.
2. Loading local data

Data must be added once the application is properly installed. The U.S. Census Bureau provides shape files containing streets and intersections for cities across the country [23]. These are the suggested ‘blocks’ in EveryBlock. Our Anchorage project used these Census Bureau’s shape files for our installation.

EveryBlock and OpenBlock use the same Python script to import block data into the database. This file, import_blocks.py, collects primary roads, secondary roads, city streets, alleys, service roads and private roads from ‘edges.shp’ and ‘featnames.dbf’ from the U.S. Census Bureau database (the Anchorage files are ‘tl_2009_02020_edges.shp’ and ‘tl_2009_02020_featnames.dbf’).

The application also requires news items to display. This project used the lifestyles (entertainment) RSS feed from the Anchorage Daily News [24] and the Anchorage RSS feed from SeeClickFix.com [25]. The successful installation of EveryBlock: Anchorage adapted the Boston-specific command line instructions provided on the eb_code group on Google Groups to Anchorage. The initial installation of OpenBlock: Anchorage adapted the Boston-specific files and scripts packaged with the OpenBlock: Boston demonstration package. The current installation of OpenBlock: Anchorage uses a clean installation OpenBlock (v0.1) with custom files and scripts.

3. Updating OpenBlock’s extension of the Everyblock source code

The installation of EveryBlock turned out to be a difficult undertaking, primarily because of the way it handles mapping. EveryBlock uses a separate module, eb_geo, to map news items. Eb_geo renders map tiles locally using the free C++-based toolkit Mapnik, which requires a fairly complicated set of interconnected libraries and plug-in dependencies. The eb_geo manual itself warns “the installation of Mapnik is non-trivial” [26].

Once eb_geo is installed, developers must create their own map tiles in Mapnik-style XML. The templates included with eb_geo do not include any maps at all at this time. Though an EveryBlock – Anchorage instance was successfully created during the course of this project, it did not include the mapping function. The Knight Foundation also addressed the installation difficulties by funding the OpenBlock project to ease the creation of EveryBlock instances [27]. OpenBlock resolves mapping difficulties by using a free base layer based on Open Street Map and hosted by OpenGeo. This bypasses the need for both the eb_geo module and Mapnik, and thus eliminating many of the problematic library dependencies for EveryBlock. This base layer is not hosted locally and the application must be able to reach Open Street Map to be able to serve the maps. This part of our project is a work-in-progress, which we will develop using OpenBlock’s Open Street Map technique for mapping.

The OpenBlock v0.1 code also simplified installation with bootstrap files for the software and a demo site (OpenBlock Demo: Boston). Bootstrap.py sets up a virtual environment and installed the Openblock software and its Python requirements while bootstrap_demo.sh loads the geographies for the city of Boston, schema definitions and some news. The scripts called by bootstrap_demo.sh, including import_boston_hoods.sh, add_boston_news_schemas.sh and import_boston_news.sh, are easy to customize for a different municipality.

![Figure 1: OpenBlock interface diagram](image)

C. OpenBlock Anchorage Results

Originally, this project had installed the EveryBlock open-source code successfully and loaded with the Anchorage TIGER/Line data and a RSS feed from the Anchorage Daily News in April, 2010 (see Figure 2). Adopting the OpenBlock code fork greatly simplifies the installation process and adds additional features into our implementation. Once the components required by OpenBlock are installed and configured on the selected operating system, the sample demo Boston site of OpenBlock v0.1 is operational with three shell commands [28]. The local demo for the city of Anchorage is similar to the OpenBlock Development Demo site and is fully functional. The updated OpenBlock Anchorage site relies on the demo site’s bootstrap_demo.sh scripts with calls to Anchorage-specific scripts in order to load data (see Figure 3).

Though the application itself is much easier to install, it still requires a local data feed. Data from the Anchorage Daily News features section RSS feed and the SeeClickFix GeoRSS feed were loaded into the application but only those from SeeClickFix contain enough information, such as latitude and longitude points, to allow mapping at this time. The administration site was also implemented and provided a simple GUI to modify the elements of its own database (see Figure 4).
CONCLUSION AND FUTURE STUDY

Although the OpenBlock project is still an alpha release, the code fork is already much easier to use and developers interested in expanding to other cities can begin to turn their attention to collecting the local data necessary to make spin-off sites useful for their municipalities. Our Anchorage OpenBlock project created a site which demonstrated how EveryBlock code, by using the OpenBlock fork, can automatically import data from a major media source into a local application in a timely manner. The application’s scope will expand as more data feeds and more available functionalities are added to the site.

Figure 2: EveryBlock Anchorage homepage

Figure 3: OpenBlock Demo (Anchorage) homepage

Figure 4: OpenBlock administration page
There are several areas we need to work on to make our Anchorage OpenBlock implementation better and smoother, including further exploration of OpenBlock’s administration utility, and improved user map search and government data search. We have also started to examine potential uses and opportunities for our block-based open news site once it is up and running. The most important and crucial fact we need to face in the second phase of this project is the sustainability of its application. How to make the site easily accessible and make its content and functionality attractive and essential to the daily life of the general public is our long-term goal. An important aspect of this phase will be to find a suitable business model and determine how to attract the critical mass of regular users needed to sustain this type of local news project.

We recognize that it is not easy to build a new, successful business, even when the idea is good and the market is receptive. Although Lisa Phillips pointed out in her new demographic report on the e-marker site - The Digital News Audience: 24/7 Participation, “The news may be unpredictable, but its appeal to consumers is not: 92% of consumers use multiple platforms to get news on a typical day, according to the Pew Research Center. These highly engaged consumers see news as a form of social currency and even as a civic obligation. Their need to keep up with current events has them searching out digital news throughout the day, checking in with more than one outlet on more than one device [29]. David Weir also mentioned in his article on bnet.com that the big win for a hyper-local service, theoretically, is local advertising. The media industry is still trying to find a successful online business model. In fact, while we are working on this project The New York Times launched a paid online model. It is too early to judge the success of the NYT experiment but we do not think it is necessary to partner with a large metro daily to create a sustainable local application.

The Anchorage OpenBlock project followed EveryBlock’s footsteps and rationale to pitch itself as a “geographic filter” that provides a “news feed” for users’ neighborhoods. The planned service provides public records from government databases, news articles from multiple sources, plus blog entries, Flickr photos, Craigslist entries, and user reviews of local businesses via Yelp [30]. Based on our preliminary study and survey, it is our belief that the potential business model we are planning to follow will be leaning toward the recommendation of David Weir described in his article [31] that “the potential business model may need to go with the alternative newswEEKlies in each community and subdivision, which have a more granular business model, including stronger relationships with local advertisers, neighborhood by neighborhood, that more closely parallels the hyper-local approach of the original EveryBlock”. As mentioned earlier in the introduction, this will be included in the future study and work of our Anchorage OpenBlock project.

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PERSONALITY, SOCIAL NETWORK SITES, AND LEISURE ACTIVITIES
– A CONCEPTUAL EXPLORATION

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ABSTRACT

Facebook, a social network site, has been experiencing a tremendous rate of growth, and today it has more than 500 million active users worldwide. Researchers have started to investigate use of Facebook and its possible impacts on our social lives. The purpose of this research is to explore possible relationships between personality, social network sites usage, and leisure activities. A conceptual model about the possible relationships was proposed. A survey is in the process of development and the authors hope possible findings can improve our understandings of interactions between personality, use of social network sites, and leisure activities.

Keywords: Personality, Social network sites, Facebook, Leisure Activities

I. INTRODUCTION

The evolution of web applications has been continuing with a very fast pace of change since the introduction of Mosaic in 1991, and it evolved into the first commercial web browser called Netscape. With Netscape, individuals and businesses have started to create personal and business websites to make sure that people can find their presence on the web. In 1994, two Stanford Ph.D. students Jerry Yang and David Filo gave birth to Yahoo, the very first search engine of the web sites. A decade later, in the Web 2.0 era, some web applications such as blogging, wikis, and social networking have caught people’s interest of creating and sharing information over the Internet. The number of users that signed up for social networking sites has been growing at an amazing speed. For instance, the most popular social network site Facebook had around 1.2 million active users in 2006, but today it has more than 500 million active users worldwide with 70 different language versions, and 70% of users live outside of the USA.

People have used their leisure time for various leisure activities, and some researchers have considered Internet usage including social networking sites as one type of leisure activities. Obviously, the time spent on Internet will decrease the time available for other leisure activities. In addition, personality may have some impacts on social networking site usage and leisure activities.

Some researchers have investigated possible relationship between personality and social networking, or personality and leisure activity, but there is no research about possible relationship between personality, social network sites usage and leisure activities. Hence, the purpose of this research is to investigate possible relationships between personality, social networking site usage, and leisure activities.

II. RESEARCH BACKGROUND

1. Social Network Sites

A social network includes people or organizations that are linked with some common interests or value [13], [27], [39]. The traditional social network focuses on face-to-face relationships, but with recent development in virtual communities, the focus has been shifted to online relationships.

A social network site can be defined as a web-based service within a bounded system that allows users to create a public or semi-public profile, to share a connection with a defined group of friends, and to view and traverse their list of connections [4]. Social network sites allow individuals to meet with strangers with similar interests, but also allow individuals to make their social network visible [17]. To join a social network site, an individual has to answer a series of questions and the answers were used to generate an individual’s profile. User profiles with demographic data, relational data, and extraordinary rate of increase, have created a fertile and attractive source of data for researchers [4], [33].

The EDUCAUSE Center of Applied Research has been conducting annual survey on undergraduate students’ use of information technology and has made its annual research study available since 2004. The 2010 research study [44], indicates that the number of respondents’ use of social network sites has increased from 81.6% in 2007 to 90.4% in 2010. The social network sites include Facebook, MySpace, LinkedIn, Flickr, Classmates, myYearbook, Tagged, Bebo and the Facebook is the most popular site with 96.6% of respondents, and MySpace is the second one with 22.5% of respondents. According to the survey, the majority of respondents used social network sites for (1) staying in touch with friends (96%), (2) sharing photos, music, videos, or other work (72.1%), (3) Finding out more about people (52.6%), (4) communicating with classmates about course-related topics (51.5%), and (5) planning or inviting people to events(50.4%). The percentage of students who use social network sites on a daily basis has increased from 32.8% in 2006 to 59.3% in 2010, and the percentage of students who has never used social network sites has decreased from 25.2% in 2006 to 9.6% in 2010.

Facebook has been experiencing a tremendous rate of growth.
In the U.S. the number of users has increased from 56.8 million in April, 2009 to 154.2 million in April, 2011 (171.6% increase), and in Asia, the number of uses has been increasing at an astonishing rate (Taiwan, 4305%, Thailand, 2959.39%; South Korea, 2599.06%). In 2006, the estimated number of Facebook users was around 1.2 million but there are more than 500 million of active users worldwide in 2010, with 70% of active users are outside of the United States, an average user has 130 friends, and people spend over 700 billion minutes per month on Facebook [11].

Obviously, the increasing popularity of social network sites has some impacts on our social lives [2], such as friendship, information sharing, and leisure activities and the huge number of users’ data has attracted researchers’ interests about possible impacts of Facebook on our social lives. Ross et al. [41] conducted a survey about the influence of personality and competence factors on Facebook use. They found that the majority of the respondents (79%) used Facebook daily for 10 to 60 minutes and different personality types did use different aspects of Facebook. For instance, people with high extraversion personality were found to join more groups than people with low extraversion personality, and people with high neuroticism personality liked to use the Facebook’s Wall, but people with low neuroticism personality preferred posting photos. People with openness liked to be socialable on Facebook.

Hew [19] reviewed current published research studies on students’ and teachers’ use of Facebook, and found nine motives of using Facebook: (1) to maintain existing relationships, (20 to meet new people, (3) using Facebook is cool, (4) to make oneself popular, (5) to pass time, (6) to express one present oneself, (7) for learning purpose, (8) as task management tool, and (9) for student activism. Most students did not use the Facebook for educational purpose. The finding is similar to the 2010 ECAR’s report on undergraduate students and information technology [44]. On average, students spent about 10 to 60 minutes daily, and the majority had about 200 to 350 friends.

Kirschner and Karpinski [29] studied possible negative impacts of Facebook on academic performance. Their research collected data about hours of Facebook use, number of groups and applications used, GPA, hours of studying, and extracurricular activities. They found that Facebook users reported lower grade and less hours of studying than non-users did and Facebook users tended to be more involved in extracurricular activities.

Lin and Lu [34] investigated why people use social networking sites and found that enjoyment, the number of peers and usefulness were the main reasons of joining social network sites, and they also found that gender difference has different influences on the number of peers and the number of members.

Pfeil, Arjan and Zaphiris [40] studied MySpace’s user profiles and age differences in using MySpace and they found out that teenagers had more friends than the older users, and teenagers had friends in their own age.

2. Leisure Activities

Leisure activities are activities that individuals participate during free time. Researchers have been trying to classify leisure activities in various patterns. Some researchers suggested that there is continuity in leisure patterns across the life span [23].

Scott and Willits [43] conduct a survey about adolescent and adult leisure patterns in 1947, and updated their data in 1998 with individuals originally surveyed in 1947. They found that adolescent leisure participation is a good predictor of adult leisure activities. Through their studies, subjects were asked about their participation in five types of leisure activities: (1) socializing with friends or relatives, (2) participating in creative or artistic activities, (3) reading or studying, (4) participating in sports, and (5) participating in fraternal or community organizations.

A questionnaire of 70 activities was developed by Hultsch et al. [21], and these activities were categorized into the following scales: physical, social, self-maintenance, passive information processing, integrative information processing, and novel information processing [22]. The original 70 activities were expanded to 82 activities and 11 activity scales: physical, crafts, games, TV, social-private, social-public, religious, developmental, experiential, technology, and travel [26].

The U.S. Bureau of Labor Statistics has been conducting an annual survey about American time use since 2003, and the data are available from its website. The American Time Use Survey [6] divided the leisure and sports activities into the following scales: (1) participating in sports, exercise and recreation, (2) socializing and communicating, (3) watching TV, (4) reading, (5) relaxing/thinking, (6) playing games and computer use for leisure, and (7) other leisure and sports activities, including travel. According to the 2009 survey, total average leisure and sports time for Americans was around 5 hours per day, which consisted of 2.8 hours watching TV, 38 minutes for socializing and communication, 23 minutes for playing games and using computer for leisure, 20 minutes for reading, 17 minutes for other leisure activities, and 15 minutes for relaxing and thinking.

Japan has a similar survey on time use and leisure activities, but it was surveyed every five year, and the most recent one was the 2006 survey [24]. Japan classified the leisure activities in 6 scales: (1) Internet use, (2) studies and researches, (3) sports, (4) hobbies and amusements, (5) volunteer activities and (6) Travel and excursions.

Brjas-Zganec et al. [5] studied possible impacts of leisure activities on social well-being of Croatian citizens. They identified 15 leisure activities of Croatian citizens and classified these activities into three leisure scales: (1) active socializing and going out (playing sports, going to cafes, clubs or pubs; attending sport events; and dinning in restaurants), (2)
visiting cultural events (visiting exhibitions; going to theatres; reading books; attending concerts; going to the movies; going to excursions or field trips; engaging in some particular hobby), and (3) family and home activities (visiting friends and relatives; shopping; going to the church; watching TV). They found that participation in leisure activities had positive effects on individuals’ social well-being.

Munson & Widmer [38] studied relationships between leisure behavior and occupational identity of college students, and they used the following leisure activities: arts and hobbies, games and sports, music, reading, social, thinking, and television. According to their study, students participated in intellectual leisure activities such as thinking, reading were more advanced in occupational identity.

Jopp & Hertzong [26] developed a leisure activity model with 11 types of leisure activities: physical, crafts, games, TV, social-private, social-public, religious, technology use, developmental, experiential and travel.

3. Personality

Several personality instruments developed for determining individuals’ personality traits or types. Among them, the most commonly used one is the Big Five Factors Model [36]. According to the Big Five model, human personality can be classified into five types: openness, conscientiousness, extraversion, agreeableness, and neuroticism. People with extraversion personality are active, assertive, energetic, enthusiastic, outgoing, and talkative. People with agreeableness personality are appreciative, forgiving, generous, kind and sympathetic, and trusting. People with conscientiousness personality are efficient, organized, planful, reliable, responsible and thorough. People with neuroticism personality are anxious, self-pitying, tense, touchy, unstable, worrying. People with openness personality are artistic, curious, imaginative, insightful, original and wide interests [36].

There have been several instruments for measuring the Big Five Factors. The longest one has 240 items but it takes around 45 minutes to complete [8]. Though it is comprehensive, but may be not suitable for many researches because of possible negative feeling from responders. Researchers have developed several short instruments such as the 60-item NEO five Factor Inventory [8]; 44-item Big-Five Inventory [25], and 100 trait descriptive adjectives [14].

The most recent one is the 10-item personality inventory (TIPI) scales developed by Gosling et al. [15]. The 10-item is suitable for situations when the primary focus of a research is on relationship between personality traits and other constructs [15].

Personality traits can be used to explain personal choices of various leisure activities. However, leisure activities are no longer limited to physical activities, playing online games or using internet are also considered as possible leisure activities. Therefore, with limited amount of time available for leisure, increasing use of internet or social network sites must have some impacts on the time allocated to other leisure and sports activities. Furthermore, decide how to allocate time among different leisure activities can be resulted from different personality traits.

Lu & Hu [35] conducted a search on the psycINFO about “personality and leisure” but found only a few empirical studies about this issue [12], [20]. Furnham [12] found that people with psychoticism personality liked combative leisure activities. Extraversion people liked competitive leisure activities such as team sports, and people with sensation-seeking personality liked various leisure activities. Hills & Argyle [20] found similar result about people with extraversion personality who liked sports clubs and team sports. People with neuroticism personality would prefer hobbies. Lu & Hu [35] focused on possible relationships between two types of personality, namely, the extraversion and neuroticism, and their choices of leisure activities. They found that extraversion individuals are interested in all leisure activities, but neuroticism individuals have shown little interest in leisure activities.

Jopp & Hertzog [26] investigated possible relationships between personality and leisure activities. They found that people with agreeableness personality tended to dislike crafts, physical activities and developmental activities, but they liked watching TV, religious activities, experiential activities and social-public activities. People with openness personality liked developmental activities and technology use, but disliked religious activities.

There are some researches about possible influences of personality on the use of mass media such as TV, music, TV, internet, blogging, and social network sites [1], [3], [7], [9], [10], [16], [28], [31], [41], [42] and [45].

Amichai-Hamburger [1] suggested that psychologists and web builders have to work together to develop user-friendly web sites based on individual differences.

Amichai-Hamburger and Vinitzky [3] investigated possible relationships between the individual personality and users’ behavior on Facebook. Their study found that there was a strong link between personality and Facebook uses. People with extraversion tended to have more friends and groups than people who were not. People with neuroticism tended to be willing to show more personal information and use private messages. People with agreeableness liked to post more pictures on Facebook. People with openness would use more features of the Facebook. People with conscientiousness tended to have more friends but less pictures loaded in the Facebook.

Correa et al. [7] studied relationships between personality and social media use, and found that extraversion and openness people liked to use social media, but neuroticism people disliked using social media.

Ebeling-White et al. [9] found people with shyness or
neuroticism personality preferred talking and making friends online. A similar study done by Ehrenber et al. [10] also found that neuroticism people liked to use instant messaging.

Kraaykamp & Eijck [28] found that the Big Five personality factors have different impacts on media preferences and cultural participation. People with openness disliked less challenging activities such as reading romantic fiction or watching soap operas, but people with agreeableness, conscientiousness, and neuroticism liked these activities.

Guadagno et al. [16] found that people with openness and neuroticism tend to be bloggers.

Landers & Lounsbury [31] investigated relationships between Big five personality and Internet usage. They found people with agreeableness, conscientiousness, and extraversion disliked Internet usage.

Tosun & Lajunen [45] studied possible relationship between personality and internet use, and found that psychoticism individuals tend to use the Internet as a substitution for face-to-face communication, but extraverted people would use the Internet as an extension of social connection.

Ryan & Xenos [42] investigated possible relationship between the Big Five personalities and Facebook usage, and found that Facebook users are likely to be extraverted, but less conscientious.

These researches supported possible relationships exist between personality and leisure activities, and between personality and social network sites, so there might be some relationships between leisure activities and social network sites. However, the authors conducted a search on the ScienceDirect database using “personality, leisure activity, social network” as key words and found no articles. After changing the key words to “personality, leisure, Internet”, there were two matched articles. One article [32] studied possible impact of Internet activities and leisure activities on quality of life, and suggested that use of Internet for sociability would decrease the quality of life, but participating in community or religious activities for leisure would improve the quality of life, but the study does not investigate possible relationships between use of Internet and community activities. The other article [46] investigated the relationship between loneliness and the use of Internet for entertainment, and found that lonely people tend to use Internet for entertainment or getting information about the entertainment world, but people with high Internet self-efficacy would use Internet for entertainment or facilitating off-line entertainment.

Mokhtarian et al. [37] did a conceptual exploration on the impacts of ICT (information and communication technology) on leisure activities and travel, and suggested that a traditional leisure activity may be replaced by an ICT activity.

In summary, though there are evidences of relationships between personality and use of social network sites, and between personality and leisure activities, but there is no research about possible relationships among personality, leisure activities and social network sites.

III. RESEARCH PROPOSAL

1. Research questions

This study examines possible relationships between personality and use of social network sites, personality and leisure activities, and use of social network sites and leisure activities. The specific research questions are as follows:

1. Will different personality traits influence individuals’ use of social network sites?
2. Will different personality traits influence individuals’ choices of leisure activities?
3. Will use of social network sites influence choices of leisure activities or choices of leisure activities influence use of social network sites?

2. Research instruments

In addition to data related to personality, leisure activities and use of social network sites, demographic data such as age, gender, income, and education will be collected.

Personality data will be collected with the TIP (Ten-Item Personality Inventory) instrument [15] to avoid negative feeling of using lengthy instrument. It will be used to assess personality with Big five traits of Openness (open to new experiences, complex vs. conventional, uncreative), Conscientiousness (dependable, self-disciplined vs. disorganized, careless), Extraversion (extraverted, enthusiastic vs. reserved, quiet), Agreeableness (sympathetic, warm vs. critical, quarrelsome), and Neuroticism (anxious, easily upset vs. calm, emotionally stable). The instrument uses a seven-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree).

To measure the leisure activities, this research will use the six scales from the American Time Use Survey: (1) participating in sports, exercise and recreation, (2) socializing and communicating, (3) watching TV, (4) reading/thinking, (5) Playing games and computer use for leisure, (6) other leisure and sports activities, including travel. Instead of asking individuals to answer the number of hours used daily for each leisure activity, the research will ask individuals to provide their time of leisure activities with a seven-point Likert scale ranging from 1 (less than 10 minutes per day), 2 (between 10 to 20 minutes per day), 3 (between 21 to 40 minutes per day),
4(between 41 to 60 minutes per day), 5(between 1 to 2 hours per day), 6(between 2 to 4 hours per day), 7(more than 4 hours per day).

Among all social network sites, Facebook has become the number one social network site, so this research will ask individuals about their Facebook usage profile. Ross et al. [41] developed a 28-item Facebook questionnaire with three categories of items including basic uses of Facebook, attitudes toward Facebook, and personal information on Facebook. Ryan and Xenos [42] shortened the questionnaire from 28 questions to 18 questions about frequency of Facebook use, and preferences for different features on Facebook. This research adopted the 18-item questionnaire developed by Ryan and Xenos [42]. The frequency of Facebook will be measured with a seven-point Likert scale ranging from 1 (less than 10 minutes per day), 2 (between 10 to 20 minutes per day), 3 (between 21 to 40 minutes per day), 4 (between 41 to 60 minutes per day), 5 (between 1 to 2 hours per day), 6 (between 2 to 4 hours per day), 7 (more than 4 hours per day). The Facebook features include 13 items: status, wall, comments, news feed, like, messages, photos, groups games, fan pages, events, notes, and chats, and with a 5-point Likert scale ranging from 1 (dislike a great deal) to 5 (like a great deal).

**IV. CONCLUSION**

This research has reviewed current researches about personality and social network sites, personality and leisure activities, but did not find any research connecting these three variables. The authors proposed a conceptual model with possible relationships among personality, use of social network sites, and leisure activities. The authors are currently developing the questionnaire, and a survey will be conducted in the Fall of 2011. The authors hope that possible findings about the survey can improve our understanding of the impacts of personality on social network sites and leisure activities and the interaction between social network sites and leisure activities.

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A Study on the Factors that Influence SNS Users’ Usage of Corporate SNS Sites: Focusing on Twitter
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ABSTRACT

Many companies are using Social Network Services (SNS) sites for their Marketing and Advertisement. This study would explain the process of using corporate SNS especially Twitter based on Technology Adoption Model (TAM). This study has established a hypothesis that three factors (Social Identity, Interaction and Trust for companies) would affect using corporate SNS. This study would survey users of corporate SNS and find whether above three factors affect TAM processes. Through the survey it would verify that above three factors affect TAM processes and perceived usefulness & ease of use affect use of corporate SNS.

Keywords: Corporate SNS site, Twitter, Social Identity, Interaction, The trust for companies

Chapter 1. Introduction

1.1 Background and Purpose of the Study

Human beings’ desire for connection is satisfied by the mechanism of people-to-people relationships such as conscious contact, conversation and sharing experience with one another. Today, the method of connection can be divided into online and offline connection. Since it is nearly impossible to prove one’s existence just by staying online, people rely on typing in their opinions or adding replies to other people’s opinions. In order to satisfy this basic desire to express one’s opinions and share them with others, the so called “Social Technology” such as Social Network Service (SNS) has emerged, and those services are growing at a remarkable pace. Facebook and Twitter are the most wellknown services and the number of users stand at tens or hundreds of millions worldwide. And companies around the world have growing interest in finding effective ways to use these SNS sites for corporate innovation or marketing. Many companies in and out of Korea have been found to be implementing a variety of customer-related activities on Twitter, in particular. Companies have recognized the utility value of the SNS and are making efforts to enhance their performance by strengthening customer contacts. However, identifying the factors that influence customers’ or potential customers’ use of corporate SNS sites rather than their personal SNS sites within the same platform will serve as an important factor that can help companies determine the direction towards which they will have to pursue in running their SNS sites. Therefore, this study will focus on analyzing the factors that can influence the users’ intention to use corporate SNS sites from the perspective of Technology Acceptance Model, thereby providing a theoretical foundation on which companies should run their SNS sites.

Since SNS sites’ interface with users differ one from another, the study will focus on Twitter, which is used by many companies.

Chapter 2. Theoretical Background

2.1 Concept of SNS and Leading Studies

2.1.1 Concept and Definition of SNS

Social Network Service is a kind of service that allows people to form online social networks. It also helps people build individual-to-group relationships, with which people can share useful information. Boyd & Ellison (2007) defined the SNS as a web-based service that helps people form individual’s profile, share the connections through people-to-person relationship, and support individual interaction with one another based on that connection[4]. The word “Social” is an English word that comes from “society,” and it implies “a gathering of people.” “Network” means “a net of relationships which is created by a series of interconnections.” The combination of these two words, “Social Network,” can be expressed as “a net of relationship where people are connected to each other.” Therefore, in a broader sense, it can be thought of as something that is similar to online communities which allow people to create relationships. However, SNS and online communities are different. Online communities are group-centered, where people with similar interests gather and form groups, whereas SNS is more of an individual-centered, where an accumulation of individual-to-individual relationship can create a bigger network[8].

2.1.2 Leading Studies on SNS

Domestic studies on SNS and mobile SNS mostly focus on the emergence of SNS, categorization of SNS types and researches on SNS of each type based on the web 2.0 concept. In addition, those studies more often than not pay attention to SNS’ function of building social relations or providing better SNS environment (centered on user interface) based on existing SNS. First, let us take a look at the studies related to SNS. Choi, Seon-ni (2009) analyzed existing SNS such as Cyworld, Myspace, Facebook and Twitter and found out how they were different from one another. For her research, in-depth interviews with SNS users were conducted, and she found out users’ usage patterns for each type of SNS[5]. Lee, Sihyung (2010) said that SNS consists of services based on human network, and with those elements SNS can increase service traffic and can even bring about network expansion to attract new users[14]. Moreover, she suggested a human network visualization model. Next, on studies related to mobile SNS, Jeon, Hee-seong and Choi, Min-soo (2009) did a research on micro-blogs as a new channel of
communication[11]. They conducted an analysis on microblogs by studying its concept, its current status in Korea and the new kind of communication characteristics. Kwon & Wen (2009) did a positive research on the factors that influence the usage of SNS[13]. With their study, they explained that there is a correlation between the intention to use SNS and altruism, tele-presence and social identity. Most of the leading studies on SNS propose ways to further activate or utilize SNS. However, it is difficult to find any research on factors that affect the usage intention in a particular context of corporate SNS, which is one of the interest parties of SNS, at a time when SNS is being utilized as a significant means of promotion and marketing for businesses. Therefore, this paper, as a positive research, will focus on the factors that affect the usage intention of corporate SNS, with users who use them as subjects.

2.1.3 Current Status of Domestic Corporate SNS Sites

Companies use SNS for three reasons. First, they use SNS as a marketing tool to secure potential customers. By using SNS, they can reach and be together with customers who use SNS, respond to their opinions and secure potential customers. Furthermore, this can be developed into an effective marketing tool for the company. Second, they use SNS as a means to listen to customers’ opinions. In the past, companies would carry out customer survey few times a year on a regular basis and reflect their opinions. However, SNS is now allowing businesses to get to know rapidly changing trend and have customer opinions real-time. Third, businesses use SNS in order to facilitate internal communications. By creating a platform which helps share knowledge within the firm, company’s performance can be enhanced. Companies are making use of SNS for these various reasons and purposes. In Korea, companies of various industries including IT companies are eagerly opening official Twitter or Facebook sites. According to a survey on the usage of SNS as of the end of 2009, among the companies that replied that they were running SNS, those that were using Twitter stood at 37%, Facebook at 29% and blog at 14%. It was shown that one third or one fourth of businesses use SNS such as Twitter or blog for marketing purposes. In the case of Korean businesses that run their SNS sites, KT and Hanwha S&C use SNS for recruit purpose, Hanwha and Industrial Bank of Korea for marketing and many other prominent companies of Korea including KT, LG Electronics and Samsung Group for customer satisfaction purpose. Furthermore, it is worth taking note at the fact that a growing number of SNS sites are run by heads of prominent conglomerates. Even though they are run as individual SNS sites, they help improve the overall image or profile of their companies since direct communication with them, which can have promotional effect on the company, is possible.

2.1.4 Twitter

Twitter began as an R&D project by Evan Williams and Noah Glass inside a startup in San Francisco. Its service was provided since March, 2006, and it was later separated from Odeo in April 2007 and turned into a newly spun-off Twitter Inc. The biggest characteristic of Twitter is that it allows users to update their opinions or any ideas by sending messages within 140 characters to their friends who have agreed on receiving messages. Since it is possible to share different people’s ideas and behaviors and exchange information through Twitter, users can get the feeling of talking with their friends. And this is why Twitter can be seen as a private media for exchanging information. Another attractive aspect of Twitter is that users can get a variety of different opinions real-time on social issues and can feel general opinions themselves. That is to say that private opinions and arguments that used to stay at private level can now be delivered to many different people real-time, and this provides a channel by which individual ideas and opinions can be connected to the rest of the world. In Korea, SNS sites such as me2day in the name of “microblog” provide services similar to that of Twitter. Since the messages are short, number of posts is high, and users do not feel a great burden for running them. In fact, Twitter is not as popular in Korea as in overseas market. Since the number of mobile devices or smartphone users was high in the overseas market, Twitter, which allows messages within 140 characters, was very popular. However, with the introduction of smartphones in Korea delayed, usage of Twitter in mobile web environment has been limited. However, with widespread of smartphones in the Korean market in 2009, the number of Twitter subscribers and the rate of its usage has rapidly grown. According to Twitter’s own report, a whopping 70 percent of users were using Twitter on mobile devices and separate social networking apps. Therefore, Twitter users are mostly in their 20’s to 40’s. Most of these people find it hard to find the time to use social media for fun, and they want to send news to others quicker than how they used to share their ideas or knowledge through blogs. Twitter allows users to deliver information to others by links[12]. Twitter is a social media that is most rapidly expanding on the internet, and the number of its subscribers is increasing at a remarkable speed. The number of Twitter users in Korea has also increased rapidly from 400,000 as of January, 2010 to 1.5 million as of June, 2010. Smartphone users can expose whatever information they want to unspecified individuals through Twitter. It is also possible for them to talk to anybody connected by web and receive responses immediately. Not only does Twitter allow users to communicate with their acquaintances but also to expand their relations to those who have common interests and even to celebrities. Korean people’s interest in Twitter has rocketed with tremendous popularity of smartphones and twitters of famous people including celebrities.

2.2 Social Identity

The theory of social identity is focusing on when and for what reasons individuals, as part of social groups, act as one[12]. Different from personal identity, social identity means an individual’s position in social group[24]. Individuals tend to behave in a way that conforms to their identity. And as their sense of belonging to a certain group gets stronger, they tend to take the success of their groups as that of their own and make concerted efforts for the group’s development and success[3]. Furthermore, in a positive research on the factors that affect usage of SNS, social identity was found to have great influence[13]. Therefore, this study will focus on identifying social identity, which has been found to be one of
the factors that affect the use of SNS, in a particular context of corporate SNS.

2.3 Interactivity
Before the emergence of the internet, interactivity was thought of as one part of interpersonal communication. In today’s internet-centered environment with the development of information technology, however, it has emerged as an important concept. Interactivity, which is the biggest characteristic of the internet, has become the subject of many studies. Definitions of interactivity can be categorized on the basis of primary focus of the authors on feature, process, perception, or combined approaches. The feature-based approach to interactivity emphasizes web site’s characteristics as media. Interactivity is a computer-based communication system ability with which senders can exchange the roles among receivers real-time or delayed-time, so that they can control the speed, format and contents of communication. In the concept of interactivity focusing on its feature as a website media, user control is emphasized. Scholars who approach the concept of interactivity in the process of exchange activities between communicators define it with their focus on communicators’ behaviors such as mutual exchange or response. Rafaeli (1988) defined interactivity as a degree of relevance that a second exchange, which is related to the first exchange, has with the third exchange in the process of a series of communication. He considered responsiveness as the basic concept of interactivity[18]. In the concept of interactivity focusing on the process of exchange between communicators, responsiveness is taken as an important factor. According to the study of Suh, Kunsoo (2003), interactivity means the level of communication or change of opinions or information between members of community[22]. Newhagen et al. (1996) was the first to verify in his study the concept of interactivity as a form of psychological status, and he defined perceived interactivity as a two-dimensional concept comprised of a sense of self-efficacy and sense of system efficacy[17]. The concept of interactivity can be defined from different perspectives, and as was studied upon in existing researches, interactivity is regarded as one of the important factors that affect online communication. Therefore, I would like to identify interactivity as an important factor that affects the usage of corporate SNS sites, out of all SNS sites which are currently emerging as significant subject of online communication.

2.4. Customer Trust
Throughout many fields of studies including psychology, politics, economics, anthropology, history and business management, the concept of trust has been attracting scholars’ attention. Some scholars such as Moorman (1993) have conceptualized trust as a sense of expectation that is created by individuals and groups in forms of words, promises and written documents, and they have defined trust as a conviction that people come to have towards the promises with others on confidence or even threats[16]. They also regarded trust as a behavioral trigger that determines mutual and long-term relationships between companies. They mentioned about the importance of trust building in relationship between groups and said that trust accompanied by immersion is a vital parameter for generating the necessary cooperative behaviors help reach successful alliance of companies[16]. In marketing, the concept of trust is regarded as a significant factor for creating and developing market relations. The relation of cause and effect that exist between buyers and sellers or securing customers and customer loyalty is generated through the medium of trust[2]. Trust becomes a significant empirical parameter that creates corporate relations with customers and further developing those relations[21]. Relationship Marketing, in particular, focuses on trust since trust is perceived as an important element in companies’ relationship marketing strategies[16]. Recently, many scholars define trust in multi-dimensional structure. Regarding this multi-dimensional definition, taking a different view on the level and dimension that comprise trust is said to clarify the influence and better explains the concept of trust[10]. The studies that have provided multi-dimensional definition of trust and its make up elements are as follows. The size of online shopping malls is an important element for trust, and they proposed a hypothesis that these elements may differ according to individual tendency on trust. Ryu, Il & Choi, Hyuk-ra (2003) conducted a study on the property of trust in B2C e-commerce and presented the characteristics of internet vendors, individuals and the environment as elements that affect trust building[20]. And as a result of their analysis, perceived size, evaluation, capacity, familiarity and the third person authentication were upheld as factors to building trust. It was also found that trust had a profound influence on the willingness to purchase company’s goods or services. The willingness to buy certain goods can make people think that on-and-offline information provided by the company as something that they need to purchase as well. Therefore, in this study customer trust for companies will be regarded and identified as an element that affect customers’ willingness to use corporate SNS sites.

2.5 Technology Acceptance Model (TAM)
When we look at the existing studies on the factors for and factors against users’ faith and attitudes in their intention to accept new information system, we can see that there are four main theories that have identified the process of users accepting information technology; the Theory of Reasoned Action (TRA), Theory of Planned Behavior (TPB), Technology Acceptance Model (TAM) and Innovation Diffusion Theory (IDT)[23]. TAM was first introduced in doctoral thesis of Davis in 1986 and was for the first time made an official theory in 1989. Since then, it has been applied several times to researches related to acceptance of information technology. In order to explain people’s behavior of using computers, Davis proposed Technology Acceptance Model with which he explained that the users’ intention to use a certain system determines actual use, and the intention to use that system is determined by users’ attitude, and users’ attitude is determined by Perceived Usefulness (PU) and Perceived Ease-to-Use (PE) that comprise two beliefs towards users’ acceptance. In TAM, PU is defined as the degree to which a person believes that

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using a particular system would enhance his or her job performance, and PE is defined as the degree to which a person believes that using a particular system would be free from effort[6]. Since the proposal of TAM in 1989 by Davis, many studies have supported the basic hypothesis of TAM, and it has now become a generalized technology acceptance model of users[8]. Since TAM has been adopted in applications to many information technologies as was identified in many researches, this study will be implemented by formulating a study model on the basis of TAM on the factors that influence the use of corporate SNS sites.

Chapter 3. Research Methodology

3.1 Establishment of Research Model
In this study, a research model shown in [Figure 3-1] is created in order to identify social identity, which has been identified in existing studies as a factor that influences the use of SNS, and interactivity, which has been proven to be a factor that influences the intention to use existing blogs or websites, in other forms of contents called “corporate SNS” from the viewpoint of TAM and also to identify a factor that influences the intention to use corporate SNS sites through customer trust towards companies that has been found to be a factor that influences intention to purchase on online shopping malls.

3.2 Research Hypothesis
In other studies, social identity has been identified to affect the intention to use SNS. Therefore, the social identity of customers who are going to use corporate SNS sites will have influence on their use of corporate SNS sites.

H1 (Social Identity)
- (a) Social Identity relates positively (quantity) to PU.
- (b) Social Identity relates positively (quantity) to PE.
Customer activities including exchange of information with companies or other customers through SNS supplements or strengthens their desire for interaction in real world. Interactions through SNS sites will influence customers’ use of corporate SNS sites.

H2 (Interactivity)
- Interactivity relates positively (quantity) to PU.
- Interactivity relates positively (quantity) to PE.
Customer trust has been found to influence customers’ intention for purchase in commercial transaction through websites (Yu, Il-la, Choi, Hyek-ru 2003). The information provided by SNS sites can be regarded as companies’ intangible goods. Therefore, customer trust will influence customers’ use of SNS sites.

H3: Customer trust towards companies relates positively (quantity) to PU.
It has been identified in the theory of TAM that PU has positive influence on intention to accept technology, and many studies have empirically shown that the PU has an influence on the intention to use information system. Therefore, the PU will have influence on usage intention.

H5: PU relates positively (quantity) to customers’ (users’) intention to use corporate SNS sites. The theory of TAM showed that the PE has positive influence on the intention to accept technology. Therefore, PE will have influence on usage intention.

H6: PE relates positively (quantity) to customers’ (users’) intention to use corporate SNS sites.

3.3 Operational Definition of Variables Studied
The operational definition of variables studied and measured items are shown in Table 3-1.

3.3.1 Social Identity
Social identity signifies the degree of perception of one’s intention to belong to a certain site through interaction with others within the SNS site[11]. And a 7 point Likert scale was used to measure social identity.

3.3.2 Interactivity
Interactivity is bidirectional behavior of users who want to share and make use of information with companies or other users of certain SNS sites by using SNS sites. The measurement was done on three items by amending and supplementing the surveyed items on the aspects of interactivity related to sharing communications and information knowledge that Heo, Seong-guk & Choi, Jaehwa (2008) had used on their study on blogs. Seven point Likert scale was used[8].

3.3.3 Customer Trust in Company
Customer trust in company is one’s inclination to trust information or to trust itself, and it is defined as individual’s belief or confidence in certain company that is accumulated by his or her on-and-offline experience in a company[10]. To measure this, the surveyed items of a study which is related to purchase intention in online shopping malls were amended and supplemented. In this study, a total of three items were surveyed, and the 7 point Likert scale was used for the measurement.

3.3.4 Perceived Usefulness
Perceived usefulness is defined as the degree to which a person believes that using a certain corporate SNS site would enhance his or her job performance[23]. Four items were included in the survey on perceived usefulness, and the seven point Likert scale was used for the measurement.

3.3.5 Perceived Ease-to-Use
Perceived ease-to-use is defined as the degree to which a person believes that using a certain corporate SNS site would be free from effort[23]. A total of three items were included in the survey, and the seven point Likert scale was used for the measurement.
3.3.6 Intention to Use Corporate SNS Site
This usage intention is defined as the degree to which users intend to peruse or use information on corporate SNS sites[23]. In order to measure this, three items were included in the survey, and the seven point Likert scale was used.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Operational Definition</th>
<th>Measured Item</th>
<th>No. of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Identity</td>
<td>Intention to belong to a certain site through interaction</td>
<td>Importance of my position in online community</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Degree of importance of online community in my life</td>
<td></td>
</tr>
<tr>
<td>Interactivity</td>
<td>Relative importance of performance in company and colleagues</td>
<td>Exchange of knowledge or information through SNS</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Degree to which SNS is used in daily life</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Smooth communication with the use of SNS</td>
<td></td>
</tr>
<tr>
<td>Customer Trust in Company</td>
<td>Personal belief or Confidence in company</td>
<td>Trustworthiness of information provided by company</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Appropriateness of information provided by company</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Acceptability of information provided by company</td>
<td></td>
</tr>
<tr>
<td>Perceived Usefulness</td>
<td>Degree of awareness on usefulness by using SNS</td>
<td>Acceptability of information provided by company</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Possibility of sharing information through SNS</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Possibility of communicating with others through SNS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Possibility of interacting with other members through SNS</td>
<td></td>
</tr>
<tr>
<td>Perceived Ease-to-Use</td>
<td>Degree of easiness to reach one’s certain level of usefulness by using SNS</td>
<td>Handiness of using Corporate-run SNS</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Convenience of understanding information provided by corporate-run SNS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Handiness of approaching corporate-run SNS</td>
<td></td>
</tr>
<tr>
<td>Intention to Use SNS Sites</td>
<td>Intention to use corporate-run SNS sites</td>
<td>Intention to continuously use corporate SNS</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Interest in corporate SNS</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Corporate SNS</td>
<td></td>
</tr>
</tbody>
</table>

Chapter 4. Expected Conclusion
A survey would be conducted on corporate Twitter users through mail, email, online, and etc. In order to identify the factors that affect users’ intention to use certain corporate Twitter, it would be composed of more than 100 questionnaires in the survey. After completion of the survey, this study would verify the research hypotheses established with SPSS. It would be supposed to the following conclusion of this study. First, the effects of perceived usefulness and perceived ease-to-use, main variables of TAM, would be identified. It would find that PU and PE have valid influence over usage intention of corporate SNS sites. Social identity, interactivity and customer trust in corporation would be identified to have valid influence over perceived usefulness, and only interactivity was adopted as a factor that have valid influence over perceived ease-to-use. It would also expect to find that social identity has no influence over perceived ease-to-use.

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WEB-BASED APPLICATION TECHNOLOGY IN SUPPORTING VMI: ENABLING FACTORS AND EXPECTED OUTCOMES

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ABSTRACT

This paper uncovers the experiences of automotive suppliers in Thailand, which have implemented web-based application to support vendor managed inventory (VMI). First, we identify enabling factors with greatest influence on the outcomes of web-based application implementation. Data was obtained from seventy tier-1 suppliers of the two biggest automobile assemblers in Thailand. Then, exploratory factor analysis was employed to construct enabling factors and outcomes of this implementation support VMI. The results indicate technology readiness is the most important enabler in implementing web-based application technology to support VMI. It is followed by leadership, and systems integration. In the implementation of such technology, it is important to understand the crucial role that management support and the deployment of relevant technical skills play in the success of such implementation.

Keywords: Web-based application, vendor managed inventory, VMI, automotive industry

INTRODUCTION

The benefits of information and communication technology (ICT) on supply chain operations are identified in many studies [6] [30] [31] for instance, suggested that the after implementing electronic data interchange (EDI) within an organization and/or web-based application between suppliers and buyers in the automotive supply chain, organizations are able to increase the data transaction capability leading to increased visibility of supply chain operations. In addition, those technologies are considered as a key organizational resource in supporting firms to create strategic competitive advantages including cost reduction and improving customer responsiveness [2]. Lo et al. [27] suggested that the key strategic roles of web-based application technology or EDI cover the following: (a) Transaction Execution: reducing the friction in transactions between members through cost-effective information flow/communication (Telephone, Fax, E-mail, and Internet); (b) Collaboration and Coordination: providing cost-efficient way to tie suppliers and buyers; and (c) Decision Support: providing assistance to managerial decisions (E-purchasing, ERP software).

In the context of the automotive supply chain, suppliers, especially tier-1, have been required by buyers (car assemblers) to adopt those e-purchasing technologies in order to reduce long-term cost of purchased components, increase the visibility of information flow, increase product customization, develop build-to-order capabilities, and manage their own inventory [1].

In this paper, experiences in implementing web-based application technology to support VMI in the automotive supply chain in a selected emerging economy country, Thailand, are presented. This industry has been considered as a flagship sector frequently regarded as a barometer measuring the current wealth of the economy. The auto industry is an important sector because automobile production is a large and varied industry [17]. Achieving efficiency within the supply chain can be a competitive imperative in this industry. The following section reviews the literature. Subsequent sections describe the research methodology, followed by findings, and conclusions and implications of the study.

LITERATURE REVIEW

In this section, the current status of the Thai automotive industry is described. Next, literature on the implementation of web-based application in supply chain management, especially in purchasing function, is reviewed. Then, it is followed by web-based application diffusion in the automobile industry. Lastly, literature on web-based application technology in supporting VMI is summarized. It is important to note that greater efforts in adopting web-based application and enhancing data transaction capability achieved through the use of this technology could enable significant customer responsiveness. E-purchasing, for example, will raise the professional practices of purchasing function through enhanced internal customer service and cost improvements [12] [36].

The Thai automotive industry: practices and policy

In an emerging economy country such as Thailand, the automotive industry has become one of the most important in the manufacturing sector in the country. This industry has contributed significantly to the rate of employment, GDP, and exports [3] [14] [37]. There are three levels of manufacturers in this industry: (a) passenger and commercial vehicle assemblers, (b) component manufacturers, and (c) supporting/equipment manufacturers (Board of Investment 1995; JICA 1995). The first level is dominated by sixteen assemblers including the Japanese big five (Toyota, Isuzu, Mitsubishi, Nissan, and Honda), the U.S. big three (Ford, General Motors, and Daimler-Chrysler), and few leading European automakers (BMW and Thai Swedish Assembly).
Total production volume of cars in 2007, 2008, and 2009, was 1.28, 1.39, and 0.99 million units/vehicles respectively (www.thaiauto.or.th).

For their tier suppliers, the second and third level, most companies are owned by foreigners through direct investment, joint venture, and technical licensing arrangements. Presently, there are 1,164 parts and component manufacturers, 850 of which manufacture parts and components in Thailand. Among these manufacturers, 358 are tier-1 suppliers, 272 are tier-2 suppliers, and 220 are tier-3 suppliers by www.thaiauto.co.th. The development of the automotive industry has also led to development in the upstream industries such as petrochemicals and plastics, automotive components, and metal and machinery.

Thailand is developing as a major offshore base for international automotive manufacturers especially Japanese and American. The Japanese Automobile Manufacturers’ Association [14] reported that exports from Thailand led the automotive industry revival throughout Asian countries. The automobile industry has been chosen as one of the major strategic industries in Thailand’s drive towards modern competitive manufacturing. However, the regional competitive situation in automobile manufacture and export is precarious. In order to respond to increasing demand from global customers and to attract more foreign investment, it is essential that the Thai automotive industry improve the cost, quality, and time-based flexibility in comparison to the same industry in the region. Most companies in this sector have implemented international quality management systems (ISO/TS16949), environmental management standard (ISO 14001), and international operations strategy including just-in-time production system, lean manufacturing, and supply chain management. In addition, these companies are able to enhance the competitive advantages of their supply chains by investing in e-purchasing through web-based order processing systems [16].

From the policy level point of view, new technology (production/manufacturing technology, ICT (including e-purchasing or web-based applications/web-based order processing system) and international operations strategy (as mentioned above) could be transferred from the parent company to the joint venture companies located in Thailand efficiently and effectively if financial and non-financial support has been well provided. The Thai Board of Investment (BOI) has an amended Skills, Technology & Innovation (STI) incentive package for projects which involve investing in research or design or developing Thai staff or supporting educational or research institutions. As a result, the rate of production/manufacturing technology, international operation strategy, and other organizational innovation/intervention diffusion has been increasing throughout the Thai automotive supply chains continuously.

**E-purchasing and Order Fulfillment**

Many companies are making more strategic purchasing through electronic channels and consequently, the supply chain is increasingly becoming a two-way, communications-rich medium. The shift to an online environment is reducing the “paper trail” of purchasing for organizations, as evidenced by the fast-growth across the board in the use of the internet for communicating with their supply base [24]. Purchasing and order-fulfillment are key processes in supply chain operations and with the growth of the internet these processes have had to be redesigned and reorganized [21]. The new forms of purchasing and order-fulfillment, which take advantage of ICT in order to digitize certain stages of these processes, are called e-purchasing and e-fulfillment. Purchasing includes all of the activities involved in acquiring goods or services and managing its flow from the supplier to the company where those will be transformed to the semi-finished products. [19] [41]. The stages of the purchasing process can be ranged from identifying the need to purchase particular goods/services to receive the purchased goods/services on-site [23]. It is important to note that e-purchasing can be defined as all of those activities required for the purchasing of goods or services which are supported by the internet system, or in general by ICT [15] [20]. More importantly, as e-purchasing is fully integrated with both internal and external systems, this allows for communication to grow into greater collaboration between buyers and suppliers. Both immediately and further on, this development will provide mutual benefit for both parties, as it facilitates partnerships and cooperation in supply chain management [38]. The concept of order-fulfillment is an important aspect of supply chain operations also.

Order-fulfillment involves managing through receiving the order, managing the transaction, warehouse management, managing transportation, customer response, and reverse logistics management [35]. Hence, an efficient e-fulfillment is the management of all interrelated processes/sub-process by using ICT. Recent trends indicate that companies are placing orders more frequent and often to manage smaller lots/batches. The consequence of this phenomenon is an intensified exchange of information among the players in the process in order to increase the flexibility and customer responsiveness [18].

The quarterly Report on Technology in Supply Management, conducted through a joint effort of the Institute for Supply Management (ISM) (formerly the National Association of Purchasing Managers) and Forrester Research provides the best snapshot of the growth of e-purchasing in the United States. The adoption rates of e-purchasing tools, techniques and protocols in the American marketplace, for example, are high [40]. Both in manufacturing and service-oriented firms and in large and small organizations, the adoption of e-purchasing methods is increasing and reaching “critical mass” in most areas. The adoption of e-purchasing systems can be considered from three perspectives, which are all organizations/industries, by comparing between manufacturing and non-manufacturing firms; and by comparing between large and small purchasers respectively. The overall trend in using internet systems for the procurement process could be considered at the usage of online methods for purchasing of direct and indirect goods and services, making use of the internet systems to
communicate and collaborate with suppliers, usage of online auctions, and adoption of enterprise-wide e-procurement tools [39]. In addition, web-based application/web-based order processing is a rapidly evolving area of e-purchasing, which is attractive to many firms because of the potential payback and improving their supply chain integration.

Diffusion of web-based application technology in the automobile industry

According to Childerhouse et al. [7], the schedules of OEMs in the automobile industry are extremely volatile and are liable to cause disruption further upstream the supply chain. This will negatively affect the efficiency of supply chains operation. In an effort to improve the efficiency of inter-organizational supply chains operation, much emphasis has been placed on the implementation of e-business tools and techniques such as web-based applications and/or Electronic data interchange (EDI). It is observed that most organizations have invested in EDI technology to share the information among supply chain stakeholders. In a discussion of EDI deployment in the supply chain, Leonard & Davis [26] suggested that EDI enables better information flow in the supply chain. In particular, they suggested that EDI can reduce errors and improve the accuracy of information exchanged in the supply chain. EDI also allows order entry to become faster and cheaper while eliminating the need for manual re-entry of data. Thus, this technology helps to reduce inventory in the supply chain while improving customer satisfaction as well as the level of customer responsiveness.

Web-based application technology (as the EDI system) in supporting VMI

Organizations are now shifting to web-based information transfer systems [13]. There is increasing number of web-based applications to support the entire supply chain’s operations, e.g., inventory management, vendor managed inventory (VMI), order management/fulfillment, and warehouse management. The benefits include linkage of ordering and accounts payable, automation of the approval process, improved business intelligence for better decision-making, and reduction of “maverick” (unauthorized) buying. Further advantages of e-purchasing and e-fulfillment through web-based application technology were identified by Muffatto & Payaro [29]. Their study found that this application leads firms to better management of the information and knowledge exchange with supply chain partners, better understanding of weaknesses, better control of supply-based operations, more accurate procurement, improves control of sales; warehouse stock optimization, better control of market trends and an increase in the number of products supplied by the main suppliers. It is also important to note that many of the costs associated with poor scheduling and inventory management can be eliminated by improving the flow of order and demand information upstream of the supply chain [8]. In addition, web-application technology enables internet-based supply chain activities to operate fast and inexpensive. As the result, customers can instantly monitor the status of their orders while the suppliers or vendor can manage their own inventory level calling Vendor Managed Inventory or VMI.

VMI is a collaboration technique that allows suppliers to take responsibility for a range of contracts and to manage inventories of agreed-upon items. [10] VMI has been widely used in the retail industry, e.g., Procter and Gamble (P&G) and Wal-Mart have successfully implemented VMI systems. Adopting full-functioned VMI systems requires a huge capital investment [5]. Lee et al. [25] investigated a web-based enterprise collaborative platform for networked enterprises. Research work with regard to implementing web-based application to support VMI is still limited.

After reviewing literature, this study found that web-based application is able to enhance inter-organizational coordination, resulting in transaction cost savings and competitive sourcing opportunities for both supplier and the buyer organization. However, organizations need to be certain that this technology has been implemented efficiently and effectively. Hence, research question was established and explored as below:

As required by major customers in the Thai automotive supply chain, what enabling factors influence the web-based application implementation to support the adoption of VMI for tier-1 suppliers?

In the next section, research methodology including survey instrument development, data collection, non-responder bias, and reliability and exploratory factor analysis are described.

RESEARCH METHODOLOGY

Survey instrument development

This study used pre-tested scales from past empirical studies to ensure their validity and reliability. The scales of enabling factors, expected operational outcomes, in implementing web-based application used in this study were adapted from previous studies by Childerhouse et al. [8], Lyons et al. [28], Lauer [24], Leonard & Davis [26],. The content and rationale of the scales is briefly described below.

The scales representing enabling factors were derived from the study of Lyons et al. [28]. The content captures technology competence, leadership, and systems integration. These scales not only reflect the technical aspect of adopted technology, but also the firm’s commitment to adapt the organizational culture, which is strongly connected with system integration within and between organizations.

Expected operational outcomes in implementing web-based application technology include increasing the degree of customer satisfaction, increasing the ability to share information between company and customers, reducing the loss of purchasing documents, increasing accuracy in purchasing and production planning, increasing the customer (assemblers) responsiveness, reducing the cost of
manufacturing, and reducing inventory level of raw materials and work-in-process (WIP). Therefore, the scale represents the focus on customer responsiveness [24] [26]. All items in the four constructs used a six-point Likert scale. The scales for enabling factors ranged from (1) not at all to (6) a great extent. For expected outcomes from implementing web-based application technology, the scale ranged from (1) worst industry to (6) best in industry as compared with competitors. The questionnaire was then pretested through interviews with procurement/purchasing managers, production planning and control department managers, academics, and system vendors who assessed its overall quality and level of understanding. Based on the results of the pretesting, the questionnaire was slightly modified in order to improve the data validity and reliability.

Data collection and profile of respondents

In this study, the questionnaires were sent to 230 tier-1 suppliers of two automobile assemblers (Japanese and American) located in Thailand. These two assemblers are top two companies in term of annual production volume. These suppliers cover the manufacturers of key parts/components including engine, frame and body, suspensions components, and electrical components. In addition, these suppliers have been required to adopt web-based application in supporting the vendor-managed inventory (VMI) system by those two major assemblers (customers) since 2006. Their experiences in implementing this technology ensure a relatively high level of maturity of obtained data. Middle to top management staff working in production planning and control function was the target respondents.

A total of 74 completed responses were received, implying a 32.17 per cent response rate. Compared with previous studies, this returned rate is acceptable [16]. There were 4 questionnaires that were discarded due to excessive missing responses, thus resulting in 70 usable cases. Table 1 presents the key characteristics of respondents involved in this study.

<table>
<thead>
<tr>
<th>Characteristics of Respondents (n = 70)</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Employees</td>
<td></td>
<td></td>
</tr>
<tr>
<td>200 or more</td>
<td>45</td>
<td>64.3</td>
</tr>
<tr>
<td>Less than 200</td>
<td>25</td>
<td>35.7</td>
</tr>
<tr>
<td>Ownership</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thai-owned</td>
<td>13</td>
<td>18.6</td>
</tr>
<tr>
<td>Foreign-owned</td>
<td>20</td>
<td>28.6</td>
</tr>
<tr>
<td>Joint-venture</td>
<td>37</td>
<td>52.8</td>
</tr>
<tr>
<td>Manufactured Parts/Components</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accessories Parts</td>
<td>6</td>
<td>8.6</td>
</tr>
<tr>
<td>Stamping Parts</td>
<td>6</td>
<td>8.6</td>
</tr>
<tr>
<td>Suspensions Parts</td>
<td>6</td>
<td>8.6</td>
</tr>
</tbody>
</table>

The result shows that the majority of respondents are electrical components, engine power transmission components, frame and body manufacturing firms respectively. Approximately sixty five per cent of the respondents are large companies with 200 employees or more. The working experience of respondents is at least 2 years in production planning and control function, which helps to ensure the accuracy of the information they provided for this study. With respect to the type of ownership of firm, 80 per cent (approximately) of respondents are foreign-owned through joint venture (53 per cent) and direct investment (28 per cent). Only 20 per cent are Thai-owned. Finally, all firms have adopted at least one international standard of management systems/standards including ISO9001:2000, ISO 14001:1996, and ISO/TS-16949: 2002.

In order to examine non-response bias in the survey data [22], the collected data was tested for statistical differences in responses and three firm characteristics (number of employees, ownership, and management system certifications) between the early and late waves of returned surveys. The last wave of returned surveys was considered to be good representative of non-respondents. Independent samples t-tests did not yield any statistical significant difference between the two groups, suggesting that non-response bias was not an issue in this study.

Reliability and exploratory factor analysis

Validity and reliability examination were carried out for the all constructs (Tables 2–3). Reliability analysis was conducted by examining the value of Cronbach’s α [11] for each extracted construct. Results showed that in each case, values of α exceeded the suggested threshold value of 0.6 [32]. Since Cronbach’s α may underestimate error caused by external factors such as differences in testing situations and respondents over time, composite reliability and average variance extracted were also examined since they are more parsimonious measure of reliability [34]. Statistics for

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame and Body Parts</td>
<td>11</td>
<td>15.6</td>
</tr>
<tr>
<td>Power Transmission Parts</td>
<td>13</td>
<td>18.6</td>
</tr>
<tr>
<td>Electrical Parts</td>
<td>14</td>
<td>20.0</td>
</tr>
<tr>
<td>Engine</td>
<td>14</td>
<td>20.0</td>
</tr>
<tr>
<td>Years of Experience in Production Planning and Control Function</td>
<td></td>
<td></td>
</tr>
<tr>
<td>More than 10</td>
<td>14</td>
<td>20.0</td>
</tr>
<tr>
<td>6–10</td>
<td>22</td>
<td>31.4</td>
</tr>
<tr>
<td>2–5</td>
<td>25</td>
<td>35.7</td>
</tr>
<tr>
<td>Less than 2</td>
<td>9</td>
<td>12.9</td>
</tr>
<tr>
<td>Management System Certification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ISO9001/14001 and ISO/TS-16949</td>
<td>42</td>
<td>60.0</td>
</tr>
<tr>
<td>ISO9001</td>
<td>7</td>
<td>11.4</td>
</tr>
<tr>
<td>ISO14001</td>
<td>14</td>
<td>20.0</td>
</tr>
<tr>
<td>ISO/TS-16949</td>
<td>7</td>
<td>8.6</td>
</tr>
</tbody>
</table>
composite reliabilities for the each extracted constructs exceeded the required threshold value of 0.70, providing further evidence of scale reliability [9].

In order to answer the research question, exploratory factor analysis with principal components analysis was then employed to investigate the uni-dimensionality of the scales/variables. Factor loadings of all items within each scale were above 0.50, providing support for the validity of measuring the latent variables using the respective sets of indicators. Values of the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy in excess of 0.50 indicated that the use of factor analysis was appropriate, and that extracted factors were distinct and reliable. This is reaffirmed by the fact that for each scale, Bartlett’s sphericity test for the null hypothesis that the correlation matrix is an identity matrix, was rejected (α = 5%).

Table 2 presents the results of exploratory factor analysis with the Varimax rotated component matrix.

Table 2 Enabling Factors (Rotated Component Matrix)

<table>
<thead>
<tr>
<th>Technology Readiness</th>
<th>Avg. (S.D.)</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge and expertise of web-based technology's user</td>
<td>4.97 (0.74)</td>
<td>0.815</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous training and education for all interested parties</td>
<td>5.01 (0.92)</td>
<td>0.795</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ability to use electronic media in communicating with customers</td>
<td>4.93 (0.76)</td>
<td>0.7645</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technological infrastructure (computer hardware/software, networks) of users</td>
<td>4.94 (0.88)</td>
<td>0.6253</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feature of web-based technology</td>
<td>4.71 (1.02)</td>
<td>0.5420</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Leadership (Composite mean = 4.855)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top management commitment and financial support</td>
</tr>
<tr>
<td>Establishing the long-term plan</td>
</tr>
<tr>
<td>Frequency of data transactions among users</td>
</tr>
<tr>
<td>Operational ability among interested parties using the web-based technology</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>System Integration (Composite mean = 4.770)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scope of system implementation (inter-organization and intra-organization)</td>
</tr>
<tr>
<td>Technological capability of systems vendors</td>
</tr>
<tr>
<td>Coordinating &amp; communication among interested parties</td>
</tr>
<tr>
<td>Total variance explained</td>
</tr>
</tbody>
</table>

Reliability coefficient

| Kaiser-Meyer-Olkin Measure of Sampling Adequacy | 0.830 |
| Bartlett's Test of Sphericity: Approx. Chi-Square | 491.920 |
| Df | 66 |

FINDING

Enabling factors in implementing web-based application

Table 2 presents the findings relating to the enabling factors in three different constructs – technology readiness, leadership, and systems integration. The composite mean among those three constructs show that technology readiness (4.912) is the most important enabler in implementing web-based application technology follow by leadership (4.855), and systems integration (4.770). This finding confirms the study of Zhu et al. [42], which indicated that the web functionalities, technology competence, and technology integration were significant facilitators in internet-based e-commerce implementation in European countries, and US and Canada respectively.

For the technology readiness construct, continuous training and education (average score = 5.01) was seen as requiring most emphasis followed in order by knowledge and expertise of users (average score = 4.97), technological infrastructure (average score = 4.94), ability to use technology to communicate with customers (average score = 4.93), and finally the features of the technology being used (average score = 4.71). With respect to leadership, top management commitment and financial support (average score = 5.14) was seen to be most important followed by operational abilities of users (average score = 4.83), frequency of data transactions (average score = 4.76), and finally long-term planning (average score = 4.69). For systems integration, the technological capability of the systems vendors was most important (average score = 4.86), followed by co-ordination and communication among users (average score = 4.84), and the scope of system implementation (average score = 4.61).

Table 3 shows the results with respect to the expected outcomes of web-based application with customer responsiveness being the singular classification. Increasing the degree of customer satisfaction (average score = 5.11) was the most important outcome, followed in order by reduction in loss of purchase order documents (average score = 5.04), increase in accuracy of purchasing and production planning (average score = 5.04), increased ability to share data with customers (average score = 4.94), reduction in manufacturing cost (average score = 4.86), increasing customer responsiveness (average score = 4.73), and reduction in inventory levels of raw materials and Work-in-process (WIP) (average score = 4.27).

Table 3 Expected Outcomes (Rotated Component Matrix)

<table>
<thead>
<tr>
<th>Customer Responsiveness (Composite mean = 4.856)</th>
<th>Avg. (S.D.)</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
</table>

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CONCLUSIONS AND IMPLICATIONS

This study has presented the experiences of tier-1 suppliers of automobile manufacturing industry that have implemented web-based application technology in an emerging economy country. Overall, the study has shown that the enabling factors for web-based application technology implementation by the respondents were technology readiness, leadership, and systems integration. With respect to the enabling factors for adopting this technology, three important extracted factors were top management commitment and financial support, continuous education and training, and knowledge and expertise of the users. This suggests that some of the skills and support issues are as important as the technological issues. With respect to the expected outcomes of implementing this technology, increasing the degree of customer satisfaction, reducing loss of documents and increasing the accuracy of production planning were the most important issues under the extracted factor of customer responsiveness. These issues which relate to process efficiency and customer focus were seen to be more important than the cost-based measures – reducing the cost of manufacturing and reducing inventory levels.

This study has important implications for practitioners and academics. For practitioners, there is the need to clearly understand the reasons for implementing web-based application technology. In this regard, the satisfaction of customers and the improved efficiency of internal operations should be paramount. It is also important to note that the roles of management support and the development of appropriate technical skills are crucial to successful deployment of technology. Well-designed action agenda in implementing this technology among suppliers, customers (assemblers), and IT system vendors leads to enhancement in absorptive capability of users. For academia, this study indicates the need for continuing research into how technology be deployed and enables the efficiency of supply chains operations by considering the resource-based view theory. While much of the benefits of technology deployment are recognized, the factors and processes that underpin successful implementation of new technology along the supply chain should be the focus of future research.

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A RESEARCH ON THE WEB2.0 VALUE CO-CREATION BUSINESS MODEL

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Chen-Yen Yao, Shih Hsin University, cherry@cc.shu.edu.tw

ABSTRACT

In recent years, with the fast development of Internet communication technologies, a large numbers of Web 2.0 companies increasingly appear including Facebook, MySpace, Youtube. Unlike Web 1.0, Web 2.0 is driven by using the Web as a platform and facilitates user participation, interactive knowledge sharing, and collaboration for value creation on World Wide Web. Meanwhile, Web 2.0 companies encourage participants to contribute content, tools, and software applications collaboratively. Therefore, how Web 2.0 companies leverage different participants including content developer, users, customers, service provider to co-create value on the platform become critical. The aim of this study is to understand the critical factors for managing successful and sustainable value co-creation business models of Web 2.0 websites. To go a step further, we hope to understand the following research questions: (1) What kind of value created by Web2.0 websites? (2) What are the important factors to attract users to participate in the value co-creation business model? (3) How to gain profits through the value co-creation business model?

This study conducts deep analyses of the existing literature and typical web 2.0 cases including Cyworld, Facebook and Salesforce.com. The results of this research propose four critical factors for managing successful and sustainable value co-creation business models of Web 2.0 websites: (1) Establishing a running smooth platform; (2) Setting up continuous participation rules; (3) Designing a mechanism to continuous creating and accumulating users’ needs; (4) Devising a fair and inspiring mechanism of value exchange among participants. We follow up describe details of the four critical success factors. This study provides an important basis for understanding the critical factors for managing successful and sustainable value co-creation business models of Web 2.0 websites. The results hope to provide insights for web 2.0 platform managers and future researches related to web 2.0 platform and value co-creation issues.

Keyword: Business model, value co-creation, value net, value exchange

INTRODUCTION

Technological advances transformed the Internet into our daily life. The Internet is currently gone through a new stage of growth, with a set of new features and capabilities becoming available to companies. These new ways can be collectively referred to as “Web 2.0.” Web 2.0 is web applications that facilitate participatory information sharing, interoperability, user-centered design, and collaboration on the World Wide Web (Wikipedia, 2011). It includes social networking sites, blogs, wikis, video sharing sites, hosted services, web applications, and so on. Many web 2.0 companies, such as Facebook, MySpace, Youtube, sense the opportunities and are engaged in this competition. In the meantime, Web 2.0 companies encourage participants to contribute content, tools, and software applications collaboratively. Therefore, how Web 2.0 companies leverage different participants including content developer, users, customers, service provider to co-create value on the platform become critical. The object of this study is to understand the critical factors for managing successful and sustainable value co-creation business models of Web 2.0 websites. To go a step further, we hope to understand the following research questions:

(1) What kind of value created by Web2.0 websites?
(2) What are the important factors to attract users to participate in the value co-creation business model?
(3) How to gain profits through the value co-creation business model?

LITERATURE REVIEW

WEB 2.0

Web 2.0 is the transformation from Web 1.0 internet-enabled delivered content to participation-based internet communities (Adebanjo and Michaelides, 2010). Web2.0 is a platform that continually updated new user content, where information is delivered through searching and collating data from many sources delivering rich user content to facilitate an “architecture of participation” (O’Reilly, 2005). Moreover, Web2.0 is a set of economic, social, and technology trends that collectively form the foundation for the next generation of the Internet. It is more mature, distinctive medium characterized by user participation, openness, and network effects (Musser and O’Reilly, 2006). O’Reilly (2005) generated the differences between web 1.0 and web 2.0 (Table 1).
Table 1 Differences between web 1.0 and web 2.0

<table>
<thead>
<tr>
<th>Function</th>
<th>Web 1.0</th>
<th>Web 2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Online linking</td>
<td>Static</td>
<td>Dynamic</td>
</tr>
<tr>
<td>Focus of use is on:</td>
<td>Companies</td>
<td>Communities</td>
</tr>
<tr>
<td>Networking architecture</td>
<td>Client-server</td>
<td>Peer-to-peer</td>
</tr>
<tr>
<td>used for sharing files such as video, music and text files</td>
<td>file is saved on one server machine</td>
<td>files are distributed across many PCs</td>
</tr>
<tr>
<td>Coding</td>
<td>html</td>
<td>xml</td>
</tr>
<tr>
<td>Webaddresses</td>
<td>Home pages</td>
<td>Blogs</td>
</tr>
<tr>
<td>Content aggregation</td>
<td>Portals</td>
<td>RSS</td>
</tr>
<tr>
<td>Getting updated information</td>
<td>Stickiness</td>
<td>Syndication</td>
</tr>
<tr>
<td>Searching</td>
<td>Directories-taxonomy</td>
<td>Tags-folksonomy</td>
</tr>
<tr>
<td>Data</td>
<td>Owning</td>
<td>Sharing</td>
</tr>
<tr>
<td>Content</td>
<td>Through publishing CMS</td>
<td>Through participating Wikis</td>
</tr>
</tbody>
</table>

Key collaboration technologies of web 2.0 include Wikis, RSS, blogging, podcasting, peer-to-peer and desktop search (Gartner, 2005). Web 2.0 firms take advantage of a lot of the techniques: (1) search, (2) link, (3) authoring, (4) tag, (5) extension, and (6) signal (McAfee, 2006). Web 2.0 has many characteristics such as dynamic content, rich user experience, user participation, metadata, web standards, and scalability (Best 2006). Moreover, Greenmeier and Gaudin (2007) consider openness, freedom, and collective intelligence are essential attributes of Web 2.0. Later, Wirtz et al., (2010) consider four characteristics of web 2.0 including social networking, interaction orientation, personalization/customization and user-added value.

**Business Model**

A business model is a methodology and a set of assumptions that explains how a business creates and earns profit in a competitive environment (Lumpkin and Dess, 2004). Business models are stories that explain how enterprises work and are the managerial equal of the scientific method, you start with a hypothesis, which you then test in action and revise when necessary (Magretta, 2002). Moreover, a business model represents the design of transaction content, structure, and governance so as to create value through the exploitation of business opportunities (Amit and Zott, 2001). The functions of a business model includes articulate the value proposition; identify a market segment and specify the revenue generation mechanism(s); define the structure of the value chain within the company and determine the complementary assets needed; estimate the cost structure and profit potential of producing the offering; describe the position of the company within the value network; formulate the competitive strategy (Chesbrough and Rosenbloom, 2002). Afterwards, a business model is a conceptual tool that includes a set of elements and their relationships and allows indicating a firm’s logic of earning money. It is a description of the value a firm offers to one or several segments of customers and the architecture of the company and its network of partners for creating, marketing and delivering this value and relationship capital, in order to generate profitable and sustainable revenue (Osterwalder, 2004).
Table 2 Four Pillars and Nine Building Blocks of a Business Model

<table>
<thead>
<tr>
<th>Pillar</th>
<th>Building Block</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>Value Proposition</td>
<td>A Value Proposition is an overall view of a company’s bundle of products and services that are of the value to the customer.</td>
</tr>
<tr>
<td>Customer Interface</td>
<td>Target Customer</td>
<td>The Target Customer is a segment of customers a company wants to offer value to.</td>
</tr>
<tr>
<td></td>
<td>Distribution Channel</td>
<td>A Distribution Channel is a means of getting in touch with the customer.</td>
</tr>
<tr>
<td></td>
<td>Relationship</td>
<td>The Relationship describes the kind of link a company establishes between itself and the customer.</td>
</tr>
<tr>
<td>Infrastructure Management</td>
<td>Value Configuration</td>
<td>The Value Configuration describes the arrangement of activities and resources that are necessary to create value for the customer.</td>
</tr>
<tr>
<td></td>
<td>Capability</td>
<td>A Capability is the ability to execute a repeatable pattern of actions that is necessary in order to create value for the customer.</td>
</tr>
<tr>
<td></td>
<td>Partnership</td>
<td>A Partnership is a voluntarily initiated cooperative agreement between two of more companies in order to create value for the customer.</td>
</tr>
<tr>
<td>Financial Aspects</td>
<td>Cost Structure</td>
<td>The Cost Structure is the representation in money of all the means employed in the business model.</td>
</tr>
<tr>
<td></td>
<td>Revenue Model</td>
<td>The Revenue Model describes the way a company makes money through a variety of revenue flows.</td>
</tr>
</tbody>
</table>

Value Network and Value Exchange

Stabell and Fjeldstad (1998) consider three distinct value configurations including value chain, value shop and value network. A value net is a dynamic network of customer/supplier partnerships and information flows. It is activated by real customer needs and is able to respond rapidly and reliably to customer preferences. A value net creates value for all of its participants including company, suppliers, and customers because of these participants operating within a collaborative, digitally linked network (Bovet and Martha, 2000). Brandenburger and Nalebuff (1996) propose value net is a schematic map designed to demonstrate all the players in the game and the interdependencies among them. Interactions happen along two dimensions. Along the vertical dimension are the firm's customers and suppliers. Along the horizontal dimension are the players with whom the firm interacts but does not transact. They are its substitutors and complementors (Figure 1). A player is a complementor if customers value your product more when they have the other player’s product than when they have your product alone. Furthermore, a player is a competitor if customers value your product less when they have the other player’s product than when they have your product alone.

Figure 1 The Value Net

Source: Brandenburger and Nalebuff (1996)
A value network generates economic value through complex dynamic exchanges between one or more companies, its customers, suppliers, strategic partners, and the community (Allee, 2000). Table three summarized three ways of value exchange in a value network including (1) goods, services and revenue; (2) knowledge; (3) intangible benefits (Allee, 2000).

### Table 3 Three Ways of Value Exchange

<table>
<thead>
<tr>
<th>Value Exchange</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goods, services and revenue</td>
<td>Exchanges for services or goods, including all transaction involving contracts and invoices, return receipt of orders, requests for proposals, confirmation, or payment.</td>
</tr>
<tr>
<td>Knowledge</td>
<td>Exchanges of strategic information, planning knowledge, process knowledge, technical know-how, collaborative design, policy development.</td>
</tr>
<tr>
<td>Intangible benefits</td>
<td>Exchanges of value and benefits that go beyond the actual service and that are not accounted for in traditional financial measures, such as a sense of community, customer loyalty, image enhancement or co-branding opportunities.</td>
</tr>
</tbody>
</table>

### Value Co-Production

In industrial value creation, customers were considered as destroying the value which producers had created for them (Ramire, 1999). An alternative view of value creation, value co-production, is customers creating value, they do not destroy it. Value is not simply 'added,' but is mutually 'created', 'reconciled', 'combined' or 're-created' among actors with different values (Ramire, 1999). Moreover, Normann and Ramirez (1989) consider five elements for a new generation offering: 1. physically tangible goods 2. human services carried out by and shared among, at least, supplier and customer persons 3. risk-sharing and risk-taking formulae among interacting parties 4. access to, or usufruct of, systems and infrastructure 5. information, manifested orally, tacitly—often based on previous experience, or in written or numeric or other symbol systems.

To sum up, Ramire (1999) proposes the main differences between Industrial View and Co-productive View (Table 4).

### Table 4 Two Views of Value Production

<table>
<thead>
<tr>
<th>Industrial View</th>
<th>Co-productive View</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value creation is sequential, unidirectionally transitive, best described in 'value chains'</td>
<td>Value creation is synchronic, interactive, best described in 'value constellations'</td>
</tr>
<tr>
<td>All managed values can be measured in monetary terms</td>
<td>Some managed values cannot be measured or monetized</td>
</tr>
<tr>
<td>Value is added</td>
<td>Values are co-invented, combined and reconciled</td>
</tr>
<tr>
<td>Value a function of utility and rarity</td>
<td>Exchange the source of utility and rarity</td>
</tr>
<tr>
<td>Values are 'objective' (exchange) and 'subjective' (utility)</td>
<td>Values are 'contingent' and 'actual' (established interactively)</td>
</tr>
<tr>
<td>Customers destroy value</td>
<td>Customers (co-)create values</td>
</tr>
<tr>
<td>Value 'realized’ at transaction only for supplier (event)</td>
<td>Value is co-produced with customer, over time-for both co-producers( relationship)</td>
</tr>
<tr>
<td>Three-sector models pertinent</td>
<td>Three-sector models no longer pertinent</td>
</tr>
</tbody>
</table>
Shari S. C. Shang & Chen-Yen Yao

<table>
<thead>
<tr>
<th>Services a 'separate' activity</th>
<th>Services a framework for all activities considered as co-produced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumption not a factor of production</td>
<td>Consumers managed as factors of production (assets)</td>
</tr>
<tr>
<td>Economic actors analyzed holding one primary role at a time</td>
<td>Economic actors analyzed as holding several different roles simultaneously</td>
</tr>
<tr>
<td>Firm and activity are units of analysis</td>
<td>Interactions (offerings) are units of analysis</td>
</tr>
</tbody>
</table>

**RESEARCH METHODOLOGY**

To understand the critical factors for managing successful and sustainable value co-creation business models of Web 2.0 websites, we chose a multiple case study approach. The case study approach is appropriate for providing insights and answers to “how” and “why” questions (Yin, 1994). This study conducts deep analyses of the existing literature and typical web 2.0 cases including Cyworld, Facebook and Salesforce.com. The reasons to choose Cyworld, Facebook and Salesforce.com as the representative Web 2.0 companies are: (1) they encourage knowledge sharing, users’ interaction and open platform; (2) they all make profits from web 2.0 websites. This study refers to Osterwalder’s research and uses five elements including customers, products, partnership network, revenue model, business strategies to analyze the business model of Cyworld, Facebook and Salesforce.com. Furthermore, this study uses Allee’s three ways of value exchange to draw the value net of three cases.

<table>
<thead>
<tr>
<th>Code</th>
<th>Value Exchange</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V(P)</td>
<td>Goods and services</td>
<td>Exchanges for services or goods.</td>
</tr>
<tr>
<td>V($)</td>
<td>Revenue</td>
<td>Exchanges for financial capital.</td>
</tr>
<tr>
<td>V(K)</td>
<td>Knowledge</td>
<td>Exchanges of strategic information, planning knowledge, process knowledge, technical know-how, collaborative design, policy development.</td>
</tr>
<tr>
<td>V(i)</td>
<td>Information</td>
<td>Exchanges of information including market, product, customers’ information.</td>
</tr>
<tr>
<td>V(V)</td>
<td>Intangible benefits</td>
<td>Exchanges of value and benefits that go beyond the actual service and that are not accounted for in traditional financial measures, such as a sense of community, customer loyalty, image enhancement or co-branding opportunities.</td>
</tr>
</tbody>
</table>

**Case Analysis and Result**

**Cyworld**

Cyworld is a South Korean social network service operated by SK Telecom. In 2005, around twenty five percent South Korean use Cyworld. In 2006, 19 million Korean use Cyworld and 80% income was generated from the sale of virtual goods. Cyworld also run overseas market including China, German, Japan, United States, and Vietnam. Figure 2 shows the value and Value Exchange of Cyworld.

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Cyworld website

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Facebook

Facebook is a social networking service and website launched in 2004, and 600 million active users in 2011. Users can create a personal profile, add other users as friends, and exchange messages, automatic notifications when they update their profile\(^2\). Figure 3 shows the value and Value Exchange of Facebook.

\(^2\) Glenn Chapman (AFP) · Facebook membership hits 500 million mark · July 21, 2010 · http://www.google.com/hostednews/afp/article/ALeqM5hX4tdF-h7Ci3SM1ymWyU0gyYsKrQ
Salesforce.com

Salesforce.com was cloud computing company founded by former Oracle executive in 1999. Its services translated into 16 different languages and currently have 82,400 customers and over 2,100,000 subscribers\(^3\). Figure 4 shows the value and Value Exchange of Salesforce.com.

\(^3\) [http://www.salesforce.com/tw/company](http://www.salesforce.com/tw/company)
CONCLUSION

The results of this research propose four critical factors for managing successful and sustainable value co-creation business models of Web 2.0 websites: (1) Establishing a running smooth platform; (2) Setting up continuous participation rules; (3) Designing a mechanism to continuous creating and accumulating users’ needs; (4) Devising a fair and inspiring mechanism of value exchange among participants. Theoretical validation and empirical testing are necessary.
WHY SHARING INFORMATION IN TEAM? A STUDY ON PROJECT -BASED IS TEAM LEARNING

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ABSTRACT

Appropriate management of the corporations among team members is important to guarantee the teamwork quality. In this study, based on social exchange theory and trust theory, we investigated the relationship between teamwork quality and both team and individual performance. Specifically, we identified two moderators, leader-member exchange (LMX) and perceived organization support (POS), which can moderate the effect from teamwork quality to both team and individual performance. Empirical study was conducted to provide support for our model. The result indicated that LMX has significant moderation effect on the relationship between teamwork quality and individual performance. POS had significant moderation effect on the relationship between teamwork quality and team performance.

Keywords: information sharing, leader-member exchange, perceived organization support, teamwork quality

INTRODUCTION

Organizations are under constant pressure to create synergies in the resources under their control [21]. Among all factors, which can influence a firm’s performance, teams and knowledge management are two areas that are often fruitful in providing increased value to the firms when they are carefully managed. Teams can increase capability, flexibility, and responsiveness [25], while knowledge management is believed to be crucial to organizational performance [1]. Various forms of collaboration between team members within the organizations can provide the foundation of project success [29]. As a result, teamwork quality (TWQ) was proved to be an important antecedent of team project success [22]. Although the conclusions of previous studies are quite consistent, depending on the work environment and organization culture, there are also other possible moderators, which could influence the relationship between TWQ and team performance. Trust, for example, can be one of them. Team members need to have confidence that information shared within the team is accurate and that team member providing the information is competent [37]. Under the organization context, there are two types of trust, conditional trust and unconditional trust [24]. While conditional trust mainly depends on favorable attitude toward the outcome of the behavior, unconditional trust mainly depends on shared values and common bond among the team members. Previous studies suggested that people with high unconditional trust tend to have more communication with each other and therefore enhance the efficiency of work flow [8]. The development of a shared understanding of the project is integral to team members’ successful agreement [20]. In other words, although the presence of conditional trust allows a team to work toward a common goal, the existence of unconditional trust can fundamentally change the quality of the ex-change relationship and convert a group of people into a team with commitment.

Therefore, the purpose of this paper is to identify factors which can enhance unconditional trust within the team and therefore moderate the relationships between TWQ and team performance. The theoretical background and hypotheses development will be discussed in the next section followed by the data analysis and discussion.

THEORETICAL BACKGROUND AND HYPOTHESES

The performance of a team is affected by the quality of teamwork. Hoegl and Gemuenden [22] develop six teamwork facets to measure the quality of interactions within team members: communication, coordination, balance of member contributions, mutual support, efforts, and cohesion. Communication indicates the properties of frequency, formality, straightness, and openness to
Exchange information among team members [31]. Coordination shows the harmonization and synchronization of team members when tasks are distributed to individuals [3]. Balance of member contributions is another factor that detects whether or not each member has contributed specific his or her knowledge or expertise to the team [36]. In addition, during the process of the team project, many tasks are interdependent from each other. Thus, being able to support mutually is also a critical factor to make the team more productive [38]. After the workload of a project is assigned, whether or not the team member can commit to the assigned task is an indicator of the effort of the team members would like to dedicate to the team. Finally, cohesion describes how keen the team members would like to stay in the team. The degree of cohesion is affected by the sense of belonging and can intensify the collaboration [30].

The analysis from [22] had confirmed that the six observed variables mentioned above pertain to the same latent construct and about 72% of variance is explained. Also, the standard regression coefficients of a linear regression between six observed variables and team quality are in the range of 0.16 to 0.22 showing all six variables have similar contribution in measuring the team quality. Thus, we will adopt all six variables as observed indicators in our model. Consistent to the previous study, we hypothesize that:

**H1:** Team Work Quality (TWQ) is positively related to the team performance.

Besides team’s success, individual’s own achievement is also an outcome of high level of TWQ. The two constructs, satisfaction and learning, were suggested to build the category of personal success of each team members [22]. High level of TWQ can lead to team members’ satisfaction with their work situation and provide an opportunity for team members to acquire knowledge and skills [4], [5], [32]. Therefore, higher TWQ will lead to higher personal feeling of achievement. Thus, in light of these theoretical investigations, we hypothesize that:

**H2:** Team Work Quality (TWQ) is positively related to the personal success.

Although, the relationships between TWQ and team and personal success were well established by previous studies, the various moderators that can influence these relationships are not clear. Thus, we would like to go a step forward to identify these factors in our study.

The Leader-Member Exchange (LMX) that was originally derived from the model of leadership called Vertical Dyad Linkage (VDL) to establish a leadership theory [9] that commonly measures the relationship between a team leader and his or her subordinates. LMX addressed the issue from a relationship-based approach. It can involve many extents of the relationships such as (a) all members and their relationships in a system, (b) the interactions between members of a dyad, (c) the interdependent patterns of their behavior, (d) the sharing of outcomes, and (e) the development of conceptions of environments, cause maps, and value [34]. Thus, the theory had been considered for several levels of analysis including group-level effect, dyad-level effect and the combination of dyads into groups [19].

Scandura et al. [33] argued that those subordinates who had high quality of LMXs were found to have high level of decision influence, regardless their superiors’ rating of their expertise. Higher quality LMX resembled social exchanges in that the exchange extends beyond what is specified in the formal job description [26], [27]. In other words, it can help to foster organizational citizenship based on the commitment and trust among the team members. Because high trust, interaction, support, and rewards characterize higher-quality LMX, there is a perceived obligation on the part of subordinates to reciprocate this higher-quality relationship [10]. The behavior of team members will be guided by the common goal of the team. The unconditional trust is higher in such team. In contrast, similar to pure economic exchanges, lower-quality LMX are limited to exchanges that take place according to the employment contract. These relationships are characterized by low trust, interaction, support, and rewards [10]. For these people in the lower-quality LMX environment, the rating from superiors is critical. The behavior of team members will be guided by the monetary reward instead. The trust in such team is conditional. Additionally, better LMX is also treated as respect between leader and subordinates and therefore enhance communication between members (Qaquebeke and Eckloff 2010). LMX was also found to have positive effect on the formation of team members’ common value toward the project and therefore increase the success possibility of the project [23]. To sum up, higher-quality of LMX is an indicator of higher level of unconditional trust. Thus, the quality of LMX can moderate the relationship between TWQ and team performance and personal success.

**H3** LMX positively moderates the relationship between TWQ and team performance. **H4** LMX positively moderates the relationship between TWQ and Personal Success.

Besides LMX, employee’s performance may also be affected by some other factors. The internal
context or culture of an organization can also influence team performance [8]. Someone believes that when an organization values the contributions from the employees and care about their well beings, such supports can incur the commitment and subsequently increase work effort. Theory of Perceived Organizational Support (POS) basically can be used to confirm this belief. POS refers to global beliefs held by employees regarding the extent to which their organizations value their contributions and care about their well-being [15]. Referring to Blau’s study [2], the perceived organizational support would be influenced by the frequency, extremity, and judged sincerity of statements of praise and approval from the organization. It implied that employees would expect an organization to provide greater reward to match their effort toward organizational goals. This expectancy can develop positive emotional bond to the organization. The social exchange view confirms that the commitment to the organization is strongly influenced by their perception of the organization’s commitment to them [12]. Thus, high level of POS will show the care and therefore lead to high level of commitment from the team members. Therefore the relationship between TWQ and team and individual’s performance can be enhanced. The team with higher POS will have more commitment to the organization. It will help to build a common value between organization and team members and therefore enhance their performance.

H5 POS positively moderates the relationship between TWQ and team performance.

H6 POS positively moderates the relationship between TWQ and personal success.

The research model is shown in Figure 1.

**Figure 1 Conceptual Research Model.**

**MEASUREMENT AND DATA ANALYSIS**

The study was conducted in a university in Hong Kong. Participants were undergraduate students who had registered in a course in business school. The course instructor was defined as the leader to all students’ teams during the data collection process. Students were divided into 13 groups. Each group was asked to find a real-world project to conduct a Web-based information system project. The project lasted for the whole semester. Thus, students had chance to work with the instructor and their clients for 13 weeks. When the project was finished, students were asked to answer a questionnaire about their teams’ quality, performance, LMX, POS, and individuals’ success. The course instructor evaluated the team performance as well.

We tried to adopt the existing measurement if they can be found. For LMX, we adopted Graen and Uhl-Bien’s measurement [19] in which a single measurement with seven items is recommended. The same measurement was also used in Schriesheim et al.’s study [35]. The measurement of POS is from Eisenberger et al.’s study [11] that adopts nine items of Survey of Perceived Organizational Support (SPOS). Students were asked to indicate their degree of agreement to these items on five-point scales ranging from "strongly disagree" (1) to "strongly agree" (5). The measurements of TWQ, team performance and personal success were adopted from Hoegl and Gemuenden’s study [22].

Since team quality, team performance and personal success are three formative second-order constructs, while the moderators (LMX and POS) are reflective first-order constructs, we cannot use repeated indicators approach [28]. Instead, here we use factor score approach to construct the second-order factor and analyze the model with all first-order factors instead of the second-order factors in measurement model. The psychometric properties of all order factors (CFA, discriminant validity, reliability) were assessed. We then took the construct score for each first order factor. Finally, we created a new model with the construct scores as the indicators of the second order construct.

For the similar reason, we cannot create moderators by product indicator approach directly. We used two-stage approach instead. (Please refer to [7] for details). We calculated construct level scores for each construct, and multiplied the construct level scores to create single indicator for interaction term.
RESULTS AND CONCLUSIONS

PLS (Partial Least Square) uses component-based estimation to maximize the variance explained in the dependent variable. It does not require multivariate normality of the data and is less demanding on sample size [6]. Compared to covariance based structural models, PLS methods are more flexible and are more appropriate for exploratory study aiming at finding new theory or extending current literature to new context [16]. Considering that our study is exploratory and conducted in a new context, we select PLS method to implement data analysis. SmartPLS 2.0.M3 was used for the data analysis.

For the measurement model, Teamwork Quality (TWQ) was modeled as a formative second-order construct with six reflective first-order constructs. Team Performance (TP) and Personal Success (PS) were modeled as formative second-order with two reflective first-order constructs. The two moderators, Leader-Member Exchange (LMX) and Perceived Organizational Support (POS) were modeled as reflective first-order constructs. The descriptive statistics is shown in Table 1.

<table>
<thead>
<tr>
<th>Construct</th>
<th>Mean (STD)</th>
<th>Composite Reliability</th>
<th>AV</th>
<th>Cronbach’s Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>COM (Communication)</td>
<td>4.19 (.64)</td>
<td>0.8681</td>
<td>0.63</td>
<td>0.8154</td>
</tr>
<tr>
<td>COO (Coordination)</td>
<td>4.09 (.73)</td>
<td>0.8753</td>
<td>0.64</td>
<td>0.8084</td>
</tr>
<tr>
<td>BMC (Balance of Member Contributions)</td>
<td>4.10 (.70)</td>
<td>0.8445</td>
<td>0.64</td>
<td>0.7237</td>
</tr>
<tr>
<td>MS (Mutual Support)</td>
<td>4.22 (.60)</td>
<td>0.8888</td>
<td>0.57</td>
<td>0.8493</td>
</tr>
<tr>
<td>EFF (Effort)</td>
<td>3.77 (.89)</td>
<td>0.8807</td>
<td>0.71</td>
<td>0.7947</td>
</tr>
<tr>
<td>COH (Cohesion)</td>
<td>4.18 (.67)</td>
<td>0.9227</td>
<td>0.63</td>
<td>0.9008</td>
</tr>
<tr>
<td>Q (Quality)</td>
<td>4.02 (.77)</td>
<td>0.8647</td>
<td>0.68</td>
<td>0.7608</td>
</tr>
<tr>
<td>TPE (Evaluation)</td>
<td>4.33 (.76)</td>
<td>0.9413</td>
<td>0.84</td>
<td>0.9058</td>
</tr>
<tr>
<td>WS (Work Satisfaction)</td>
<td>4.09 (.73)</td>
<td>0.8890</td>
<td>0.72</td>
<td>0.8127</td>
</tr>
<tr>
<td>L (Learning)</td>
<td>4.19 (.67)</td>
<td>0.8980</td>
<td>0.69</td>
<td>0.8800</td>
</tr>
<tr>
<td>LMX (Leader-member Exchange)</td>
<td>3.48 (.53)</td>
<td>0.8050</td>
<td>0.45</td>
<td>0.6958</td>
</tr>
<tr>
<td>POS (perceived organization support)</td>
<td>3.51 (.85)</td>
<td>0.9081</td>
<td>0.52</td>
<td>0.8864</td>
</tr>
</tbody>
</table>

For all constructs, the internal consistency and convergent validity were evaluated by examining the item construct loading, average variance extracted (AVE), composite reliability, and Cronbach’s Alpha value. Convergent and discriminant validity is inferred when the PLS indicators (1) load much higher on their hypothesized factor than on other factors (own-loadings are higher than cross-loadings), and (2) when the square root of each construct’s average variance extracted (AVE) is larger than its correlations with other constructs ([6].

For individual item reliability, item loadings are higher than 0.60. The Alpha values are higher than 0.72. We also calculated item cross-loadings based on the procedure recommended for PLS [17]. Each item loaded higher on its principal construct than on other constructs (please see Table 2). While cross-loadings derived from this procedure will be inevitably higher than from typical exploratory factor analysis, the cross-loading differences were much higher than the suggested threshold of 0.1 [17]. All AVE were larger than 0.53 except LMX which is 0.45. The convergent validity of all constructs except LMX was good.

<p>| Table 2 Correlation Matrix and Average Variance Extracted for Principal Constructs. |
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The 11th International DSI and the 16th APDSI Joint Meeting, Taipei, Taiwan, July 12 – 16, 2011, pp.274-280
Consistent to the previous studies on team performance, we found that TWQ has significant effect on both team and individual’s success. The result confirmed that TWQ is a fundamental factor to team project success. The individual members can also learn from the success process and therefore enhance their own perceived achievement. Although LMX moderated the relationship between TWQ and individual success, the moderating effect on the relationship between TWQ and team performance was not significant. This might be due to that LMX is dyad relationship between supervisor and team member. It is personal orientated and indicated the relationship between individuals. If a team member cannot feel be appreciated by his/her supervisor, the perceived achievement can be lowered. However, since the goal of the team project is clear, low LMX will not influence the whole team’s performance.

POS was found to moderate the relationship between TWQ and and individual success but not the relationship between TWQ and individual success. The perceived organization support was mainly from project’s client. The support was offered to accomplish the project. Therefore, it was project orientated. Lack of such support will make the project process slower down. However, if the project failed in this way, the individual will perceive that the reason of failure is because the lack of support from client rather than lacking essential of himself/herself. As a result, lack of POS will not influence individual’s own evaluation.

**DISCUSSIONS AND CONCLUSIONS**

This study identified two moderators, LMX and POS, for the relationship between TWQ and team and individual’s success. Specifically, LMX moderated the association between TWQ and individual success while POS moderated the one between TWQ and team performance. The results had higher generalization since the students were asked to conduct real-world projects rather than a course project during data collection process.

Based on the results, there are some implications to industry. First, since TWQ is a fundamental factor of team project success, an organization needs to consider providing more friendly environment and organization culture to enhance TWQ. Secondly, since LMX can moderate the relationship between TWQ and individual success, a team leader should interact with members patiently to link the corporate goal to individual goal. Finally, the organizational support is always important for team members to dedicate themselves for better team performance.
REFERENCE


EXPLORING THE ANTECEDENTS INFLUENCE OF KNOWLEDGE SHARING INTENTION

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ABSTRACT
The knowledge sharing issue between organization and employee, has been the focus on knowledge management activity. Although many organization established knowledge repositories and system, but there are still have many obstacle factors that hinder knowledge interaction and disseminate. This study attempts to exploring the antecedents affecting the interflow of knowledge, and proposal framework to reveal factors, such as, anticipated reciprocal relationship, perceived of ethics, and resource availability. Meanwhile, the framework integrate theory of reasoned action (TRA) for delve into affecting knowledge providers psychological factors related, and expect employed by the knowledge management academic or practice domain.

Keywords: Resource availability, Perceived of ethics, Theory of reasoned action, Knowledge sharing

INTRODUCTION
"Knowledge" is to organize an important strategic asset and source of core competitive advantage, with knowledge of innovative knowledge creation and organization of intellectual capital, began the organization of knowledge sharing among members. Once the members will be materialized knowledge as personal assets, the sharing of personal knowledge is often not in line with management. The expectations of how employee of the organization for knowledge sharing in the conflict, employee find out the real contribution of induced motivation and knowledge to help guide the organization or company to establish a platform for knowledge sharing, and then produce the innovation key to success.

[22] argued that allow members to share and promote knowledge is the knowledge management of the biggest problems. [13] further pointed out that more sharing of knowledge is often not in line with personal management (unnatural), because people think their knowledge is valuable and important to compete for resources, and thus will not be willing to share light trading. [15] also found that the claim is equivalent to put them personal share some self-delivery of the future. In practical experience, by proposal many managers, consultants and scholars have also pointed out that knowledge sharing is knowledge management a very important and also very difficult subject, the key often is not technical, but people [14]. According to the knowledge base view (KBV), through the invisible nature of knowledge and social system complexity create major knowledge market. Market knowledge is intangible knowledge goods, the price system is not clear and practical norms, but the interaction between human psychological closely. Therefore, the operation of market knowledge is human rather than mechanical. Organizations face the wave of knowledge economy, how knowledge is the key success factors of enterprise innovation, knowledge market is particularly important. [14] for empirical knowledge sharing intention of the study suggested that knowledge owners because of mutual interest doctrine, reputation, altruism and other rewards knowledge sharing, knowledge sharing caused by intent. On the other hand look at the future, scholars [8] claimed that the knowledge is difficult to measure value, and that knowledge is not filled with the results of trading the stability of the two sides there may be speculative trading tendencies, so that knowledge of the transaction costs, so that failure of the knowledge market. Documents can see from the above, how members are willing to share knowledge, promote organizational knowledge flow of the first task, to learn more about members to share knowledge attitudes and intentions has become a knowledge sharing and communication of important issues.

THEORETICAL BACKGROUND

Knowledge Sharing
If organization to promote knowledge sharing and for using, the effectiveness of the organization is also very important [10]. Therefore, through knowledge sharing not only can accelerate the learning between groups members, more correction can be made for the organization great value. [22] suggested that knowledge sharing is a process of communication, knowledge in the time to learn from others (to share knowledge for others), there must be reconstruction of the behavior must have the knowledge to learn that knowledge, share knowledge, refresher knowledge sharing involves "knowledge owner" (intentionally willing to speech, writing, behavior, or other means to communicate knowledge of the future) with the "knowledge demanders" (able to imitate, listen or read the future way of understanding, understanding knowledge are) two of the main. Hence, [12] argued that knowledge sharing is to learn from other individuals to experience process, it can also mean the process of knowledge transfer. Knowledge exists in the brain of employees, cannot be raised if shared with others, you cannot play a role, is bound to lose value, only to their own knowledge and application sharing with others, to create for the organization more high value and performance [23]. Knowledge sharing between employees for the increase in the value and impact of learning may both positive and favorable growth of the organization and innovation [27]. [14] claim that knowledge is a competitive advantage in organizations, but also have sustainable competitive advantage. Knowledge sharing is knowledge
creation and reuse of a premise, if the individual has not been to share knowledge, knowledge of the effectiveness of the limited personal. The significance of knowledge sharing, is to carry out knowledge transfer, absorption and play, enables organizations to growth.

**Theory of Reasoned Action Model**

The theory of reasoned action (TRA) due to [6] proposed in the fields of social psychology, is often used to explain the wide range of individuals interested in knowledge of behavioral intention. This theory is to study personal knowledge of the behavior within the care model. According to TRA of the basic assumptions, individual behavior based on rationality, their thought is a systematic [26], is the individual's behavior is based on their get the message, and make a systematic and rational of the activities taken after. The TRA of the universal description, discovery of a specific individual behavior is determined by its behavior intention the decisions, and behavioral intentions, it is by individual behavioral attitude and subjective norms are determined.

**Behavioral Attitude (Attitude Toward Behavior)**

[7] proposed that in rational action theory, the decision to individual behavioral intention another factor affecting the individual to society, this factor is defined as "acts of personal involvement with a particular positive or negative evaluation between". Based on [5], which is referred to the personal traits of attitudes and attitude refers to an individual person, and things or actions would take the positive or negative assessment, reflecting an individual who and things or malicious feeling good behavior. Behavioral attitude refers to individuals in a particular behavior may be the result of the feelings held by the reported attitudes held.

**Subjective Norm (Subjective Norm)**

[7] suggested that the TRA, the decision to individual behavioral intention another factor affecting the individual to society, this factor is defined as "society for individuals engaged in specific behaviors and any given pressure ", that is subjective norm. Subjective norm refers to the execution of a behavior is too personal, feel the other important relationships people would accept his behavior, their attitudes and behavior that is the relationship between knowledge because people are interested in thinking through the process to decide a specific situations, whether the intention of engaging in certain behavior. Namely, subjective norm is a person perceived to everyone on his or her views of exercise behavior. [7] pointed out that the behavior is sometimes affected by the impact of social environment, stress, greater than the impact of individual attitudes. That is, at some point, we can determine the attitude and behavioral intention; some cases, subjective norm the leading behavioral intentions.

**Behavioral Intention (Behavioral Attention)**

TRA proposed the individual's behavioral intention to predict the optimal behavior variables. [21] addressed the definition of behavior intention "to engage in specific behaviors intensity of spontaneous plan". Other words, also known as personal behaviors like to work in a particular subjective probability [5]. Own personal behavior, the stronger the intention, on behalf of the more likely to engage in the behavior. In summary, TRA is a conceptual model it did not specify the particular beliefs or behaviors. Therefore, for all on the attitude or behavior pattern research, often for different behavior by identifying the relevant belief, and then through the rational behavior theory to explain the future, that is, speaking from the capture user use attitude, facilitate a system can infer that the internal psychological acceptance in the personal level or impact [18].

**THE CONCEPTUAL FRAMEWORK AND PROPOSITIONS**

**The Relationship between Anticipated Reciprocal Relationships and Attitude toward Knowledge Sharing**

Between members of the organization anticipated reciprocal relationships, can capture the needs of employees, to continue to maintain the relationship to others, especially the provision of knowledge sharing and receiving [10]. Employees can feel the expected reciprocal relationship between the value of their own, while employees can share their knowledge through which to capture their value provided for the organization [19]. And this value refers to the individual based on their ability to make a contribution to the organization. [24] proposed that affect individual knowledge sharing in attitude pointed out, these constructs fit the theory of social psychological forces.

The two organizations will be the environment in which individuals and society affect individual tendencies and attitudes, especially in the non-specific knowledge sharing. In addition, the individual state of social exchange is an important factor affecting attitudes [10]. Social exchange theory of the invisible social costs and benefits of the exchange, these do not have clear rules and treaties to restrain management. Both economic and social exchange theory were assumed when an individual's compensation is greater than the cost to take part only when the exchange, economic exchange theory is the emphasis on external interests, the emphasis on social exchange theory intrinsic rewards [33, 9, 20]. Social exchange does not guarantee the investment costs will be provide the same, because there is no clear rules and treaties to manage the interaction between the two sides, but no specific rights and obligations. The process of knowledge sharing is the social interactions between individual, so the use of social exchange theory to explain the knowledge sharing behavior should be very suitable. For these reasons, the presentation of the first proposition:

**P1. When knowledge providers have more confidence in their anticipated reciprocal relationships for knowledge sharing, they would tend to develop a more favorable attitude toward knowledge sharing. That is, the anticipated reciprocal relationships of a knowledge provider will have a positive effect on its attitude toward knowledge sharing.**

**The Relationship between Perceived of Ethics, Attitude toward Knowledge Sharing and Subjective Norm**

[17] Positive peer pressures on individuals have significant impact on ethical behavior. TRA is not a personal sense of
morality (moral obligation) to include within the framework of a formal model, but include Ajzen and many scholars believe that the personal sense of morality is the number of potential antecedents [4, 1, 29]. In other words, influence individual behavior intention of important factors, in addition to behavior and attitude and subjective norm, the personal sense of morality will also affect the behavioral intention to establish.

[16] investigated subjective norms of ethical behavior on the marketing impact of personnel, marketing personnel found that significant others if its implementation is not ethical behavior of a stress, the more he will lower the implementation of the act, but also stronger subjective norms that people tend to take more consistent with group expectations of behavior. [30, 28] according to the theory of organizational behavior that herd behavior, obey authority; groupthink will hinder the establishment of individual ethical intentions. [4] defined sense of morality for the individual to refuse to perform an act or an act of moral feeling or sense of responsibility, the feeling of personal values related to personal morality will affect everyone and everything related to ethical dimensions of evaluation. Base upon TRA, behavior and attitude for the individual for a specific act of subjective perception and evaluation of good and evil, which is an individual agree or not to adopt a behavior tendency. In this study, interested organizations, and workers, the work of ethical behavior, that is, the ethics of the workplace, the behavior and attitude for the work ethic and for individuals to implement a particular ethical issue involved in the conduct held by the positive or negative evaluation. Affect the intention of the second factor acts as subjective norms refer to individuals engaged in certain conduct expected of social pressure. Acts of individual work ethic subjective norm refers to individuals in the workplace, the subjective view that if in a particular ethical behavior relating to the social pressure to bear, that is personal to others that "he should or should not adopt a certain behavior" perceptions [16].

As mention above, this study suggests that the ethical principles of morality derived from individual (ethical principles). Base on these above inferences, the proposition 2 and 3 is state as below:

P2. When knowledge providers have received more positive perceived of ethics from other organizational members, they would tend to develop a more favorable attitude toward knowledge sharing. That is, the perceived of ethics of a knowledge provider will have a positive effect on its attitude toward knowledge sharing.

P3. When knowledge providers have received more perceived of ethics support to share knowledge, they would tend to develop a more favorable subjective norm. That is, the perceived of ethics of a knowledge provider will have a positive effect on its subjective norm.

The Relationship among Resource Availability, Attitude toward Knowledge Sharing and Intention to Share Knowledge

[11] Resource availability can be define as can generate the resources to accommodate and draw resources, scheduling of resources available to the system requirements and other distribution resources. From the resource availability and system level, volatility of demand, resource availability can be provide with the system at any time and the demand generated. In practice, availability of resources is an uncertain factor, such as participation in the auction, scheduling and when the transactions. Therefore, the competitive environment requires appropriate measurement and the trustworthiness of the availability of computing resources, which must be based on the participation of individual attitudes and behavioral intentions and resources around the equipment cases [11]. That is, when the individual possesses enough resources available for some time, can strengthen the individual acts adopted by the attitudes and behavioral intentions, but can also increase the individual's trust.

Research indicates that as the importance of population size; often compete with different people, which relations between available resources and the availability of closely related tasks. Resource availability will affect and interfere with the actual employee performance, depending on the employee's strategy choice, and the determination of maintenance tasks [31]. In other words, this means that employees who perceived resource availability and job performance are linking, and then the more enhanced the impact of attitude on behavior and behavioral intentions of activity. A physician bedside rationing on the European study mentioned by the observation of physician availability and the available resources, the association found between attitudes will affect the disease epidemic [25]. Which will affect the physician’s moral judgments at the time treatment behavioral intentions? Accordingly, this study stated the following propositions:

P4. When knowledge providers have perceived more resource availability support to share knowledge, the greater attitude toward knowledge sharing will be affected to share knowledge. That is, the resource availability of a knowledge provider will have a positive effect on the attitude toward knowledge sharing.

P5. When knowledge providers have perceived more resource availability support to share knowledge, the greater intention to share knowledge will be affect to share knowledge. That is, the resource availability of a knowledge provider will have a positive effect on the intention to share knowledge.

The Relationship among Subjective Norm, Attitude toward Knowledge Sharing and Intention to Share Knowledge

Theory of reasoned action to develop three main inferences: 1. the individual's intention to perform an act is to determine the major factor in whether the conduct occurred. 2. The individual acts in the production of intent will not be change or increase or decrease before. 3. Individual behavior influenced by individuals of the potential control of reason and the will [1, 2]. The third point, however, assumes that the application of the theory of reasoned action to generate many restrictions, because human behavior is not entirely rational and under the control of the will, sometimes in the actual implementation must meet objective, which involves
the issue of personal control. If to be able to make a behavior, individuals must have the ability to control different external variables, so that the desired behavior can thus produce [3], thus extending the concept of gradually developed into a theory of planned behavior. We discover that behavior of individual attitude is from individuals believed that such practices will have some impact, but these effects through the assessment is positive and active. Subjective norm is arising from external social pressures, and makes the individual to decide whether to take such action. Both will directly affect the individual performance of specific acts of intention. From this, the core TRA behavior is assume the actual behavior of individuals by its behavior intention the decision and behavior intention by another act of behavior and attitude and subjective norm affected. Base on the mention above, this leads to the propositions 6, 7, 8 is state as below:

**P6.** The greater the subjective norm to share knowledge is, the more favorable the attitude toward knowledge sharing will be. That is, the subjective norm of a knowledge provider will have a positive effect on its attitude toward knowledge sharing.

**P7.** The greater the subjective norm to share knowledge is, the greater the intention to share knowledge will be. That is, the subjective norm of a knowledge provider will have a positive effect on its intention to share knowledge.

**P8.** The more favorable the attitude toward knowledge sharing is, the greater the intention to share knowledge will be. That is, the attitude of a knowledge provider will have a positive effect on its intention to share knowledge.

Through analysis of the literature, this study proposes a conceptual framework shown in Figure 1. The framework described the knowledge of individual providers of knowledge-sharing attitudes, subjective norms and sharing of intentions. In this study, we advocate, is anticipated reciprocal relationships and perceived of ethics from the individual psychological relations with the individual can control the resource availability, such as three factors that affect the TRA, when the antecedent variables are treated as an exogenous variable to explore the three constructs to influence knowledge sharing (endogenous variables) generated by relationships.

**CONCLUSION AND CONTRIBUTION**

In this study, merge with the TRA as the main core theory framework, and refer to scholars [10] proposed anticipated reciprocal relationships, perceived of ethics [32] and [11] advocates the resources availability such as the three antecedents to exploring the individual’s knowledge sharing intention of the case. Throughout much of the literature, only a few scholars to discuss the availability of resources owned by individual intent on knowledge sharing related, this research use by analyzing the relevant literature review, concluded that combined to derive the concept of the framework. In addition, this study expected to fill the gap of knowledge management academic theory. More notable, this paper offers realistic knowledge sharing conceptual that in an innovative, knowledge intensive organization context, flexibility in inter-organizational relationships is an important key point ideas. In the future work will be proceeded with the empirical study to verify the proposition, which, in turn, go further attest to this study usefulness and interpretation of organization for knowledge sharing between inter-organization employees.

**REFERENCES**


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EXPLORING THE ANTECEDENTS OF INNOVATION CAPABILITY - THE MEDIATING ROLE OF KNOWLEDGE SHARING ORIENTATION

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Abstract
This research creatively employs the constructs of employee job satisfaction, knowledge sharing, and innovation capability as a conceptual research framework. How to enrich job satisfaction to facilitate innovation and enhance value creation is one of the most important strategic weapons to aid in business competition. This research will study the mediating role of knowledge sharing interaction with regard to job satisfaction and innovation capability. Hence, we propose a theoretical model and test related hypotheses by the use of the LISREL 8.8 maximum likelihood estimate program.

Keywords: Job satisfaction; Knowledge sharing; Innovation capability

Introduction and literature review
In the related research fields of job satisfaction, knowledge sharing, and innovation management, most studies view innovation capability as supported by the way employees access, learn, accumulate and utilize knowledge. Innovation capability may thus be closely related to employee performance, and the goal of this research is to empirically study this relationship. After that, this research proceeded with a questionnaire survey to examine the validity of the hypotheses. It is expected that the results of this research will be valuable to both academics and practitioners.

Job satisfaction
Job satisfaction is an important topic, and it is seen as having a wide-ranging number of effects in organizational research. Locke (1976) defined job satisfaction as a pleasurable or positive emotional state resulting from the appraisal of one's job or job experiences. Hulin and Judge (2003) noted that job satisfaction includes multidimensional psychological responses to one's job, and that such responses have cognitive, affective, and behavioral components. For the organization, job satisfactions mean a workforce that is motivated and committed to high quality performance. In addition, satisfied employees are more likely to have good mental health and be better at making adjustments in their lives [26]. Locke (1976) proposed that satisfaction is determined by a discrepancy between what one wants in a job and what one has in a job. Judge et al. (1998) argued that there are four core self-evaluations, self-esteem, general self-efficacy, locus of control, and neuroticism, that determine one's disposition towards job satisfaction. Judge et al. (1998) also stated that higher levels of self-esteem, general self-efficacy, having an internal locus of control, and lower levels of neuroticism lead to higher job satisfaction. Herzberg (1968) stated that there are motivation and hygiene factors in the workplace that cause job satisfaction. In addition, motivation can be seen as an inner force that drives individuals to attain personal and organization goals [36]. For the organization, increased productivity—the quantity and quality of output per hour worked—seems to be a byproduct of greater job satisfaction. Therefore, the importance of creating a positive working environment cannot be overemphasized, and so job satisfaction remains an important research topic.

Knowledge sharing
Nonaka (1991) said that "In an economy where the only certainty is uncertainty, the only sure source of lasting competitive advantage is knowledge". Organizations thus recognize that knowledge constitutes a valuable intangible asset for creating and sustaining competitive advantages [28], and its value can be shared through knowledge management processes. Such management includes the fields of business administration, information systems, management, and library and information sciences [1]. More specifically, Teece (2000) stated that knowledge management involves the panoply of procedures and techniques used to get the most from an organization’s both tacit and codified know-how. In other words, knowledge sharing is a critical element in organizational learning, performance improvement, competitive advantage, innovation, and any other organizational improvement.

Innovation capability
Innovation is a key topic in the study of business, entrepreneurship, economics, technology, and knowledge management. In the organizational context, innovation may be linked to performance and growth through improvements in efficiency, productivity, quality, competitive positioning, market share, and so on. Schumpeter (1934) noted that innovation is a prime mover of economic change, while Thompson (1996) defined it as the generation, acceptance, and implementation of new ideas, processes, products, or services. Burgelman et al. (2004) defined technological innovation capabilities as a comprehensive set of characteristics of an organization that facilitates and supports its technological innovation strategies. Since innovation capability is an integrative ability to manage different key organizational capabilities and resources successfully [25], the well managed innovation capabilities that can enable the practice of innovation activities in the organization.
Conceptual framework and hypotheses development

Relationship between job satisfaction and knowledge sharing

Job satisfaction is important in organizational behavior, and it is based on the individual employees’ subjective perceptions and feelings. In studies of the relationship between job satisfaction and personal characteristics, most indicate a positive association between age and job satisfaction [38]. In addition, various learning processes and associated types of knowledge have been identified as characteristic of a learning organization [18]. Bussing et al. (1999) suggested that job satisfaction is developed through an assessment of the match between expectations, needs, and motives and the work situation. The relationship between employee rights to satisfactory employment conditions, employee responsibilities in decision-making, and employee willingness to share their knowledge collaboratively has also been investigated [21]. Koys (2001) found that employee satisfaction, organizational citizenship behavior, and turnover had a positive relationship with organizational effectiveness.

Hendriks (1999) stated that “Knowledge sharing presumes a relationship between at least two parties” The owner of the knowledge shares through the process of externalization, and the recipient internalizes knowledge. The former can involve writing books, attending meetings and performing tasks can take the form of observing others, learning on the job, reading books and accessing and assimilating knowledge from knowledge data bases. For instance, Bock and Kim (2002) propose that self-efficacy could be treated as a major source of self-motivation for the knowledge sharing behavior of individuals. On the other hand, it is possible drawback of providing clear incentives on willingness to share knowledge. Consequently, we expect that job satisfaction could facilitate the knowledge sharing process.

Hypothesis 1:
Job satisfaction is positively related knowledge sharing.

Relationship between knowledge sharing and innovation capability

Nonaka’s (1994) dynamic theory of organizational knowledge creation holds that it is created through a continuous dialogue between tacit and explicit knowledge via four patterns of interactions, socialization, combination, internalization and externalization. In order to respond to the complexities of the environment, there is a level of stretch requiring the company to incorporate innovation and creativity in the efficient use of resources [29], and new ideas and solutions require knowledge and expertise [30]. Studies on organizational innovation have focused primarily on identifying the environmental and organizational conditions that facilitate or inhibit adoption of innovations [10]. The generation of innovation is a process that results in an outcome that is new to an organizational population, and the adoption of innovation is a process that results in the assimilation of a product, process, or practice that is new to the adopting organization [11]. Van de Ven (1986) defines the process of innovation as “the development and implementation of new ideas by people who over time engage in transactions with others within an institutional context”. New ideas and solutions require knowledge and expertise [30]. Thus, integrating the ideas set out above, we propose that knowledge sharing can enhance innovation capability in organizational relationships.

Hypothesis 2:
Knowledge sharing is positively related to innovation capability.

Mediating effects of knowledge sharing orientation

Hypotheses 1 propose that job satisfaction affect knowledge sharing while Hypothesis 2 suggests that knowledge sharing is positively related to innovation capability, and Hypothesis 3 propose that job satisfaction has positive relationship to innovation capability. These causal chain relationships indicate that knowledge sharing plays the role of intermediate variable in mediating the relationships between independent variables of job satisfaction, and dependent variable of innovation capability. From this viewpoint, job satisfaction would influence innovation capability primarily through intrinsic knowledge sharing. Accordingly, this study proposes the following hypotheses

Hypothesis 4:
Knowledge sharing tends to have positive mediating effects on the relationship between job satisfaction and innovation capability.
Methodology

The conceptual research model

The objective of this study is to investigate the interrelationships among employee job satisfaction, knowledge sharing, and innovation capability (see Figure 1). Specifically, this study attempts to explore the influence of job satisfaction and knowledge sharing on innovation capability, as well as the mediating effects of knowledge sharing orientation on the relationship between job satisfaction and innovation capability are evaluated.

Data collection & sampling frame

The empirical study employed a questionnaire to collect data for testing the validity of the model and research hypotheses. Besides, in order to reduce the problem of common method variance (CMV) which may have influenced the results, job satisfaction and knowledge sharing constructs were answered by employees and innovation capability constructs were answered by his/her direct supervisors. Out of the 450 questionnaires distributed, 325 were returned, giving a response rate of 72%.

Construct measurement and data analysis

In our study, job satisfaction was measured with twenty items from the Minnesota Satisfaction Questionnaire (MSQ, 1977), which were adapted to the current study (The Cronbach’s alpha for this scale was 0.85). Knowledge sharing was measured with seventeen items that were developed by Bock and Kim (2002) (The Cronbach’s alpha for this scale was 0.81). Innovation capability was measured with nine items adapted from the work of Scott and Bruce (1994), which capture the expectations for individual episodes of innovation (The Cronbach’s alpha for this scale was 0.92). Besides, Seven-point Likert scales were used in the questionnaire (1=“strongly disagree”, 7=“strongly agree”). In order to test our hypotheses, we conducted structural equation modeling (SEM) analyses using LISREL 8.8 with maximum-likelihood estimation. Following the suggestions of Anderson and Gerbing (1988), we adopted a two-stage approach to test the structural equation model. We used the overall model Chi-squared index, the goodness-of-fit index (GFI), the comparative fit index (CFI), the normed fit index (NFI), the incremental fit index (IFI), the root mean square error of approximation (RMSEA), and the standardized root mean square residual (SRMR) to assess the model fit.

Results

Table 1 presents the means, standard deviations, reliabilities, and correlations of the study variables. The results show that job satisfaction, knowledge sharing are significantly related to innovation capability (r=-0.25-0.31, all p values <0.05), and job satisfaction is positively and significantly related to knowledge sharing (r=0.59, p values <0.01).

Table 1 Means, S.D., and intercorrelations among variables

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<th>S.D.</th>
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<tr>
<td>1. Job Satisfaction</td>
<td>5.47</td>
<td>0.85</td>
<td>0.82</td>
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<td></td>
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<tr>
<td>2. Knowledge Sharing</td>
<td>5.61</td>
<td>0.76</td>
<td>0.72**</td>
<td>0.75</td>
<td></td>
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<tr>
<td>3. Innovation Capability</td>
<td>3.70</td>
<td>0.57</td>
<td>0.25**</td>
<td>0.31**</td>
<td>0.75</td>
</tr>
</tbody>
</table>

Note: (1) * p < .05; ** p < .01 (two-tailed); N = 325
(2) AVE coefficients are presented in boldface on the diagonal.

Confirmatory factor analyses

As can be seen in Table 2, the results showed that the 2-factor model, and the 3-factor model provided a more adequate fit than the 1-factor model, and Chi-squared difference tests showed that the χ² decrement between the 1-factor model, the 2-factor model, and the 3-factor model, was significant. Moreover, the factor loadings of all items in the 3-factor model were statistically significant (p <0.01), suggesting that the convergent validity of all measures was acceptable.

Table 2. Results of confirmatory factor analyses
Hypotheses testing

In order to test Hypotheses 1, Hypotheses 2, and Hypotheses 3, we followed Baron and Kenny's (1986) suggestion to assess the first condition of mediation. As can be seen in Table 1, the correlation coefficients indicate that job satisfaction, knowledge sharing are significantly related to innovation capability (r=0.25-0.31, both p values <0.01), and job satisfaction is positively and significantly related to knowledge sharing (r=0.72, p values <0.01). Moreover, as can be seen in Figure 2 and Table 3, the results of the direct effects of job satisfaction, and knowledge sharing on innovation capability were statistically significant (standardized total effects 0.72 and 0.28, both p values <0.05) as well as acceptable model fit measurement. Therefore, Hypotheses 1, Hypotheses 2, and Hypotheses 3 were all supported. For Hypotheses 4, we assessed the conditions of mediation. The path coefficient of job satisfaction to knowledge sharing (β= 0.72, p <0.01), and the path coefficients of knowledge sharing to innovation capability (β=0.28, p <0.01) were all positive and significant. In order to test whether indirect effects of the dependent variable via the mediators exist, we performed Sobel tests to examine the statistical significance of the three mediated relationships [35][39]. We followed the suggestions of Preacher and Hayes (2004) and coded the standard error of path coefficients (from the fully mediated model), and calculated the critical ratio as a test of whether the indirect effects were significantly different from zero. The results of the Sobel test confirmed the existence of significant mediating effects of job satisfaction (Z=0.18, p< 0.01), on innovation capability via knowledge sharing. Therefore, Hypotheses 4 were supported.

Figure 2. Standardized structural equation model with maximum-likelihood estimates

Note: χ²/df =2.56, GFI=0.87, CFI=0.93, IRI=0.93, IFI=0.93, RMSEA=0.07, SRMR=0.05 All indicators and correlations among the exogenous variables are not included. *p <0.05; **p <0.01 (two-tailed).

Table 3. Results of overall model fit measurement

<table>
<thead>
<tr>
<th>Fit indicators</th>
<th>Parameter</th>
<th>Recommendation criteria</th>
<th>Research model values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>χ²/df</td>
<td>&lt;3</td>
<td>2.56</td>
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<td>model fit</td>
<td>SRMR</td>
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</tr>
<tr>
<td></td>
<td>GFI</td>
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<td>AGFI</td>
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<td></td>
<td>NFI</td>
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<tr>
<td></td>
<td>CFI</td>
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<tr>
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<tr>
<td></td>
<td>RFI</td>
<td>&gt;0.9</td>
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</tr>
<tr>
<td></td>
<td>RMSEA</td>
<td>&lt;0.05</td>
<td>0.07</td>
</tr>
</tbody>
</table>
Conclusions and implications

As this research sample was composed of Taiwanese companies, it is important to discuss the specific findings for the future development of such firms. Our research findings can serve as important references for these companies. It is urgent for firms to develop an appropriate environment inside the organization to foster both job satisfaction and knowledge sharing, as this can greatly aid innovation. This study thus attempts to investigate how to develop an appropriate environment, wherein job satisfaction can be created and strengthened by utilizing knowledge sharing processes. Nevertheless, innovation capability at Taiwanese enterprises is the sum of all the employees’ efforts in the organization. In other words, companies in Taiwan are situated at a pivotal position to build internal mechanisms to enhance the self-efficacy and effectiveness of workers. In this regard, our research findings can provide ideas for firms to develop and consolidate the relationship among employee job satisfaction, knowledge sharing, and innovation capability. In this respect, it is critical to identify and develop an optimal innovation capability pattern for Taiwanese enterprises.

Acknowledgement

This paper has benefited greatly from the comments and suggestions from the track chair and the anonymous referees of the Technology and Innovation Management track. The author would like to gratefully acknowledge the financial support for this research from the National Cheng Kung University, Taiwan.

References

[8] Chung-Jen Wang & Ming-Tien Tsai


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THE IMPACT OF SUPPLY INFORMATION SHARING ON SUPPLY CHAIN COST AND SERVICE LEVEL PERFORMANCE

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ABSTRACT

A simulation model with mixed-integer programming was built to simulate operating activities with and without supply information sharing in a three-level capacitated supply chain consisting of multiple suppliers, one manufacturer and multiple retailers. The simulation results indicate that supply information sharing can significantly reduce total cost and enhance service level of the whole supply chain. The impacts of supply information sharing on the supply chain cost and service levels are heavily influenced by demand patterns and capacity availability.

Keywords: Supply Chain Cost and Service Level, Information Sharing, Simulation

1 INTRODUCTION

Current business competition shifts from individual businesses versus individual businesses to supply chain versus supply chain. Coordinated supply chain management has become the paradigm of modern business operations. Chopra and Meindl [3] claimed that four major drivers, inventory, transportation, facilities, and information, determine supply chain performance. Because information directly affects each of the other drivers, information sharing is a prerequisite for better coordination and planning of supply chain activities.

According to the direction of information flow between supply chain members, information sharing can be classified into two categories: demand-side information sharing and supply-side information sharing. Previous literature already made a wide variety of insightful explorations into information sharing of the demand-side in supply chain, however, research efforts have rarely been made into supply-side information sharing. The purpose of this paper is to scrutinize information sharing from the supply-side and its impact on a multi-level supply chain. A simulation model with mixed-integer programming was built to simulate ordering, production planning, and supplying activities with and without supply information sharing in a three-level capacitated supply chain consisting of multiple suppliers, one manufacturer and multiple retailers.

The following sections present a review of related literature, the research methodology, the proposed research model, and the research hypotheses. Subsequently, we analyze the research results and conclude with a discussion on the major research findings.

2 LITERATURE REVIEW

2.1 Supply Chain Structure

It is almost impossible to include the whole scope of supply chain in academic research. Therefore, it is necessary to construct supply chain structures that are complex enough to be representatives of reality and simple enough to be dealt with for research.

The supply chain concept grew largely out of two-stage models [1]. However, a complete supply chain process model should include source, make, and deliver from suppliers to customers [17]. A three-level supply chain that consists of a manufacturer, its immediate suppliers and customers includes these three processes. Therefore, three-level supply chain is a good balance between the closeness to reality and research complexity.

For three-level models, Iyer and Ye [9] and Munson and Rosenblatt [14] are both concerned with serial supply chain, whereas Lau, Huang, and Mak [12] dealt with a divergent supply chain. These studies assume only a single product being distributed in the supply chain. Therefore, multiple products could be a direction for extension.

2.2 The Types of Information Sharing

Research on demand-side information sharing has been highlighted over time [7]. However, what information could be shared from supply side and what the impact would be have rarely been considered. A supply chain faces uncertain market demands for end products from one side and unstable supply of raw materials or components from another side. There is no reason to emphasize one but overlook the other.

Kim, Leung, Park, Zhang, and Lee [11] developed a mathematical model that considers a supply chain consisting of a manufacturer and multiple suppliers to explore how much of each raw material is to be ordered from each supplier under the constraints of capacities of suppliers as well as the manufacturer. They concluded that the manufacturer has to consider its own production capacity, its suppliers’ capacities, market demand uncertainty, under-stocking and overstocking costs to reach optimal procurement decision. The limitation is that planning
horizon only extends up to one period.

Swaminathan, Sadeh, and Smith [18] analytically investigated sharing supplier capacity information with a downstream manufacturer who orders raw materials from two alternative suppliers differing in cost and capacity to produce a single product. The study showed that although information sharing is beneficial to overall supply chain performance, it can be detrimental to individual members. The findings are only built on a simple two-tier supply chain structure for a single product in a single period horizon.

Lee and Whang [13] indicated that capacity information sharing can contribute to mitigating potential shortage gaming behavior, thereby countering a potential source of the bullwhip effect. Huang, Lau, and Mak [8] indicated that sharing capacity information in a supply chain is essential for integrated planning.

2.3 Supply Chain Modeling Approach

The modeling approaches have basically fell into three categories: analytical models, mathematical programming models, and simulation models.

Analytical models are quite popular in supply chain management field. Such models are effective in providing important insights into information sharing issues. For example, Lee, Padmanabhan, and Whang [13] analytically proved the existence of four sources of the bullwhip effect. Basically, analytical models deal with operational issues under simple supply chain structure and appear in the early literature.

Mathematical programming models are mostly used to formulate strategic issues in supply chain management, such as facility location selection [10], supplier selection [11], global resources deployment [4], and supply chain planning [6].

Simulation approach utilizes computer technologies and programming languages to imitate the operation of a system so that the behavior of the system under specific conditions can be studied. Simulation models describe how a supply chain will operate over time as a function of parameters and policies [16].

Simulation approach has some intrinsic advantages. First, it has greater flexibility that decision makers prefer. Second, it has the ability to replicate and isolate probabilistic functions and activities within a system for specific study. Third, it can be used to explore the impacts of qualitative factors on a supply chain. Fourth, it can be closer to real systems than analytical and mathematical programming models.

The representative discrete event simulation studies that focus on information sharing include those of [5], [7], [20], [22].

Based on our observation of the existing literature, simulation approach is the right choice for modeling complex supply chain structure (e.g. network structure).

3 RESEARCH METHODOLOGY

This paper uses a hybrid approach of computer simulation and mixed-integer programming (MIP). A computer program is built to simulate the operations of a three-stage manufacturing supply chain by using C++ and runs on a Dell PowerEdge 4400 server with Linux operating system.

3.1 Basic Assumptions

We make the following assumptions to simplify the establishment of supply chain model:

1) The supply chain consists of three capacitated suppliers, one capacitated manufacturer, and four retailers.
2) The manufacturer produces two functional products in a make-to-stock process, which consume the same key resource and can substitute each other to some extent. Production lead time is assumed to be zero. Capacity absorption rate for both products is equal to one, that is, one unit of product needs one unit of resource to produce.
3) Each product needs two components (raw materials), and one of the two components is a common component. The usage rate of all the raw materials for the two products is one.
4) The retailers are confronted with uncertain, time-varying customer demands for both products. The average demand for each product is 1000 units at each period. In turn, the manufacturer faces demands from the retailers for replenishing their inventories, so the retailers’ average demand for each product is 4000 units at each period. Sufficient initial inventories are provided for each retailer and the manufacturer to avoid not having enough inventories to satisfy demands at the beginning of the simulation. The manufacturer needs to place orders for raw materials to its suppliers when inventories of raw materials are not enough.
5) The lead times of placing orders from the retailers to the manufacturer and from the manufacturer to raw material suppliers are assumed to be zero.
6) The suppliers are end suppliers; thus they do not need to order raw materials from other suppliers to make their own products.
7) The manufacturer employs MRP system to organize its production activities.
8) Each supplier is the only provider for the manufacturer for one specific raw material, and the manufacturer is the only customer for each supplier.
9) Transportation lead times from the suppliers to the manufacturer and from the manufacturer to the retailers are assumed to be one period. Transportation capacity of a vehicle is assumed to be large enough for any large order.
10) Downstream partners pay for the regular transportation cost, and upstream partners pay for backorder transportation cost.
11) The determination of cost structure: All cost figures are from a real case of a local beverage plant whose supply chain structure is similar to the one we studied. The transportation costs from manufacturer to
The suppliers to the end. SIT generates a capacity utilization of 75% with the plant's it rs. SIS means cipcation t isnormal in (t)

These demand patterns are generated for four retailers by demand with seasonality and increasing trend. SDT demand with seasonality without tr
ts normal (i=1,2,3,4; t=0,1,2,..., 299); Base is the initial demand which is selected to ensure that the average demand for each product during all simulation period is 1000; Slope describes the increasing or decreasing trend of demand; Season represents the magnitude of seasonal variation of demand; SeasonCycle is the cycle of the seasonal variation of demand, and its value is 7 in this study to represent a weekly fluctuation; Noise is the magnitude of random disturbance; snormal() is a standard random function. To avoid the possibility of generating negative demand, we restricted the standard normal random variable to values within the range of -3.0 to +3.0 only.

The characteristics of these demand patterns are summarized in Table 3.2 and Table 3.3.

Table 3.2 The Characteristics of Demand Patterns of Product 1

<table>
<thead>
<tr>
<th>Demand Patterns</th>
<th>Product 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>Slope</td>
</tr>
<tr>
<td>SEA</td>
<td>1000.00</td>
</tr>
<tr>
<td>SIT</td>
<td>761.00</td>
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<tr>
<td>SDT</td>
<td>1239.00</td>
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</table>

Table 3.3 The Characteristics of Demand Patterns of Product 2

<table>
<thead>
<tr>
<th>Demand Patterns</th>
<th>Product 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>Slope</td>
</tr>
<tr>
<td>SEA</td>
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</tr>
<tr>
<td>SIT</td>
<td>551.00</td>
</tr>
<tr>
<td>SDT</td>
<td>1449.00</td>
</tr>
</tbody>
</table>

3) Capacity Tightness (CT)

CT reflects how tight production capacity of the manufacturer is, comparing with the demand it faces. It is defined to be the ratio of the total available capacity to the total capacity needed. It is the reciprocal of capacity utilization. Because we assume the capacity absorption rate is one, that is, one unit of product needs one unit of resource to produce; the total demand to be satisfied is equivalent to the total capacity needed. Therefore, the total available capacity equals the total demand to be satisfied times CT. We assume that available capacity is evenly distributed over all simulation periods. Three levels of capacity tightness, Low (1.33), Middle (1.18), and High (1.05), which correspond to capacity utilization of 75 percent, 85 percent and 95 percent, respectively, are set in the simulation. These CT values are also employed in [2], [21], [22], and [23].
3.2.2 Dependent Variables of the Experimental Design

Cost and service levels have been used as the dependent variables of the experimental design to measure the supply chain performance:

- Total cost of retailers (TCR): the sum of ordering cost (including transportation cost), inventory carrying cost and the backorder cost for the retailers.
- Total cost of suppliers (TCS): the sum of the transportation cost (for backorder delivery), inventory carrying cost and the backorder cost for the suppliers.
- Total cost of manufacturer (TCM): the sum of the setup cost, order processing cost, transportation costs (for backorder delivery), inventory carrying and the backorder cost for the manufacturer.
- Total cost of the supply chain (TC): TCR+TCS+TCM (backorder cost paid by the manufacturer to the retailers and by the suppliers to the manufacturer).
- The service level of the supplier (SLS): the percentage of manufacturer’s orders satisfied by the supplier.
- The service level of the manufacturer (SLM): the percentage of retailer’s orders satisfied by the manufacturer.
- The customer service level of the retailers (SLR): the percentage of customer demand satisfied by the retailers; SLR is also the actual external service level performance of the entire supply chain.

3.3 The Simulation Procedure

The simulation program developed by [20] and [22] was used to simulate forecasting, ordering, and supplying activities in the supply chain. Genetic algorithm for general capacitated lot-sizing problem (GCLSP) developed by [19] was modified to solve MIP model for the manufacturer’s lot-sizing issue. An interface was built to link these two parts so that simulation parameters could be transferred interactively between them.

4 RESEARCH HYPOTHESES

Four hypotheses will be tested in this study:

Hypothesis 1
The supply information sharing (SIS) will significantly improve the performance of supply chain members and the whole supply chain.

Hypothesis 2
Demand patterns faced by the retailers (DP) will significantly influence the value of supply information sharing.

Hypothesis 3
Capacity tightness of the manufacturer (CT) will significantly influence the value of supply information sharing.

Hypothesis 4
Demand patterns faced by the retailers (DP) will significantly influence the impact of capacity tightness (CT) on the value of supply information sharing.

5 RESULTS AND DISCUSSIONS

The outputs from the simulation experiments were analyzed by using Analysis of Variance (ANOVA). The selected results are presented in Table 5.1 and Table 5.2. We can see that all the main effects and the interaction effects are significant in terms of total cost and service level at 1 percent significance level. To examine the impact of the independent variables on the dependent variables, Duncan’s multiple-range test was performed to rank their performances. The results are presented in Table 5.3 and Table 5.4. The discussions, which centered on the research hypotheses, are presented below.

Table 5.1 Selected ANOVA Results for Cost Performance

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>TC</th>
<th>Pr&gt;F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source</td>
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</tr>
<tr>
<td>1 SSIS</td>
<td>4756.45</td>
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</tr>
<tr>
<td>2 DP</td>
<td>538.97</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>3 CT</td>
<td>533.70</td>
<td>&lt;.0001</td>
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<tr>
<td>4 SSIS*DP</td>
<td>321.78</td>
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<tr>
<td>5 SSIS*CT</td>
<td>553.60</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>6 SSIS<em>CT</em>DP</td>
<td>257.16</td>
<td>&lt;.0001</td>
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</table>

Table 5.2 Selected ANOVA Results for Service Level Performance

<table>
<thead>
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<th>SL</th>
<th>Pr&gt;F</th>
</tr>
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<tr>
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<td>3 CT</td>
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<td>5 SSIS*CT</td>
<td>1348.03</td>
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<tr>
<td>6 SSIS<em>CT</em>DP</td>
<td>236.99</td>
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</table>

Table 5.3 Duncan’s Grouping Results of Relative Total Costs

<table>
<thead>
<tr>
<th>Simulation Parameters</th>
<th>Value</th>
<th>Performance Measures</th>
<th>Rank</th>
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</thead>
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<tr>
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<td>RTC</td>
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<tr>
<td>SSIS</td>
<td>NIS</td>
<td>150.30</td>
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</tr>
<tr>
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<td>SIS</td>
<td>100.00</td>
<td>1</td>
</tr>
<tr>
<td>DP</td>
<td>SEA</td>
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<td>1</td>
</tr>
<tr>
<td></td>
<td>SIT</td>
<td>102.56</td>
<td>2</td>
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<td></td>
<td>SDT</td>
<td>109.08</td>
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</tr>
<tr>
<td>CT</td>
<td>LOW</td>
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<td></td>
<td>MID</td>
<td>101.63</td>
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<td></td>
<td>HIGH</td>
<td>106.25</td>
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Table 5.4 Duncan’s Grouping Results of Service Levels

<table>
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<tr>
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<tr>
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<td>DP</td>
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<tr>
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<tr>
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<tr>
<td></td>
<td>HIGH</td>
<td>82.70</td>
<td>3</td>
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</tbody>
</table>

5.1 The Impact of Supply Information Sharing (SIS) on the Supply Chain

Figure 5.1
Main Effect of SIS on Relative Total Cost (RTC)

Figure 5.2
Main Effect of SIS on Service Level (SL)

Figure 5.3
Interaction between DP and SSIS on Relative Total Cost (RTC)

Figure 5.4
Interaction between DP and SSIS on Service Level (SL)

From Figure 5.3, the cost saving that was brought by supply information sharing is decreased when the demand pattern changed from SIT to SDT. Hence, demand trend has an influence on the value of supply information sharing in terms of cost saving.

Figure 5.4 shows that SIS improved service level across all demand patterns. Whether supply information is shared or not, SEA achieves the highest service level, and follows SIT and SDT. In terms of the magnitude of improving the service level, we can see that although SEA achieves the highest SL, the service level improvement under SIT is slightly higher than that under SEA to be the largest. SIS information sharing has more powerful effect on total cost reduction than on service level improvement.

By knowing supply information from its suppliers, the manufacturer can develop a feasible production schedule that satisfies its internal constraints and external constraints, simultaneously. On the other hand, through sharing supply information with the retailers, the manufacturer can reduce backorders cost and transportation cost by selling substitute products to the retailers. Meanwhile, knowing supply information from the manufacturer, the retailers can adjust their purchasing plans by moving the procurement lot-sizes for products backward or by buying substitute products, thus reducing backorders and increasing sales.

Based on these observations, hypothesis 1 is supported.

5.2 The Influence of DP on the Value of SIS

From Figure 5.3, the cost saving that was brought by supply information sharing is decreased when the demand pattern changed from SIT to SDT. Hence, demand trend has an influence on the value of supply information sharing in terms of cost saving.

Figure 5.4 shows that SIS improved service level across all demand patterns. Whether supply information is shared or not, SEA achieves the highest service level, and follows SIT and SDT. In terms of the magnitude of improving the service level, we can see that although SEA achieves the highest SL, the service level improvement under SIT is slightly higher than that under SEA to be the largest. SIS information sharing has more powerful effect on total cost reduction than on service level improvement.
makes the least improvement in the service level under SDT.

When DP=SIT, if there is no supply information sharing, retailers have to rely on inventories accumulated at earlier periods in order to satisfy backorders at later periods. If supply information is shared, taking advantage of this information, retailers can rearrange their purchasing plan by moving orders at later periods to earlier periods. Therefore, supply information can play a key role in reducing backorders.

When DP=SDT, backorders mostly appeared at earlier periods. Even if supply information is shared, retailers cannot move orders at the earliest periods to earlier periods. Therefore, supply information may not be able to reduce backorders too much. That is why service level improvement under SDT is the lowest.

When DP=SEA, the demands faced by retailers have only seasonal up-and-downs without trend. Even though backorders may appear at some periods, they can be quickly filled by additional supply capability at subsequent periods, so backorder will not remain unsatisfied, and additional inventories will not be stored for a too long period of time. Therefore, backorder cost and inventory holding cost may not be too high. When supply information is shared with retailers, they can take initiative action to adjust their purchasing plans by moving the lot sizes backward to reduce possible backorders. As a result, the backorder cost can be further lowered, but the cost saving achieved and service level improvement may not be as high as those under SIT.

Based on these observations, we can see that DP has a significant influence on the value of SIS.

5.3 The Impact of CT on the Value of SIS

To analyze the impact of capacity tightness on supply information sharing, we portrayed the relative total cost (RTC) and service level (SL) of the supply chain for different combinations of CT and SSIS in Figure 5.5 and Figure 5.6.

As shown in Figure 5.5, when there is no supply information sharing, the decrease in extra capacity has a negative impact on total cost. The more stringent capacity is, the higher the total cost becomes. Moreover, the increase in total cost is in an increasing rate. When there is supply information sharing, the total cost also increased with the decrease of extra capacity, but in a smooth increasing rate. Hence, the cost saving from supply information sharing becomes larger when extra capacity becomes less.

For the impact on service level, as shown in Figure 5.6, when there is no SIS, the service level declines consistently when capacity tightness ranges from Low to High. When there is SIS, the service level has been greatly improved under CT=High and CT=Mid. However, the service level improvement is not obvious when CT=Low. Therefore, the service level improvement increased with the increase of capacity tightness.

The reason behind these phenomena is that when capacity tightness is low, the manufacturer’s production capacity is already sufficient for satisfying the demand from retailers. Shared supply information exerts little influence in reducing backorders through adjusting retailers’ procurement plans. In other words, there is not much difference between supply information sharing and no supply information sharing in terms of improving supply chain performance. However, when capacity tightness becomes higher, there is less extra capacity against backorders. Under such circumstance,
supply information can be used by retailers to revise their purchasing plans in order to match the supply capability of the manufacturer, thus reducing backorders. Therefore, the supply chain cost and service level were improved in a larger degree. Therefore, hypothesis 4 is supported.

5.4 The Influence of DP on the Impact of CT on the Value of SIS

To examine the interaction effects among DP, CT and SSIS, we plotted the relative total cost (RTC) and service level (SL) of the supply chain for different combinations of CT and SSIS under different demand patterns in Figure 5.7 to Figure 5.12, respectively.

Figure 5.7 Interaction between CT and SSIS on Relative Total Cost (RTC) when DP=SDT

![Figure 5.7](image1)

Figure 5.8 Interaction between CT and SSIS on Service Level (SL) when DP=SDT

![Figure 5.8](image2)

From Figure 5.7, we know that RTC was decreased greatly across all CT levels through sharing supply information. When there is no supply information sharing, RTC is the lowest when CT=Low, and then it increased slowly with the decrease of extra capacity. RTC increased further when capacity became even tighter. However, when there is supply information sharing, RTC increased consistently in a steeper rate as CT increased from Low to High. The cost saving is decreased with the increase of CT.

Correspondingly, Figure 5.8 shows that the service level reaches the highest level when CT is Low, and is reduced to the lowest level when CT is high whether supply information is shared or not. The service level under SIS reduced a little faster than that under NIS when CT ranges from Low to High. Therefore, service level improvement is decreased with the increase of CT.

These observations can be explained by two reasons. First, when demand has a decreasing trend, capacity is lower than demand at early periods. Backorders mainly occur at earlier periods. However, during these earlier periods, even though supply information is shared, retailers have less room to change their purchasing plans by moving purchasing orders to even earlier periods, thus sustaining backorders at a higher level, especially when capacity tightness is high. Second, when capacity tightness is low, supply deficiency is not severe during earlier periods, and capacity at later periods can also be used to satisfy previous backorders. However, when capacity goes tighter, capacity at later periods is not enough to satisfy early backorders. Therefore, the cost saving and the service level improvement under low and middle capacity tightness are higher than those under high capacity tightness.

Figure 5.9 Interaction between CT and SSIS on Relative Total Cost (RTC) when DP=SEA

![Figure 5.9](image3)

Figure 5.10 Interaction between CT and SSIS on Service Level (SL) when DP=SEA

![Figure 5.10](image4)

Figure 5.9 shows that when there is supply information sharing, RTC is the lowest when CT is Low, is slightly increased when CT changed to Mid, and continues to increase to the highest level when CT became High. When there is no supply information sharing, RTC grew in a little steeper rate when CT increased from Low to High. The cost saving is increased with the increase of CT.
As shown in Figure 5.10, when there is supply information sharing, the service level first dropped gradually when CT varies from Low to Mid, then declined a little faster when CT became High. When there is no supply information sharing, the service level declined consistently when CT increased from Low to High. Service level improvement is increased with the increase of CT, but under CT=Low, there is almost no improvement in service level.

These observations can be explained as follows. SEA does not have an increasing or a decreasing trend. Even if capacity becomes tighter, this feature makes backorders be quickly filled by excess capacity at following periods. In addition, by knowing supply information, retailers can move larger-than-capacity lot-sizes backward as much as possible. Therefore, the supply chain can lower the total cost and improve the service level in a larger magnitude when capacity is less sufficient.

These observations can be explained as follows. SEA does not have an increasing or a decreasing trend. Even if capacity becomes tighter, this feature makes backorders be quickly filled by excess capacity at following periods. In addition, by knowing supply information, retailers can move larger-than-capacity lot-sizes backward as much as possible. Therefore, the supply chain can lower the total cost and improve the service level in a larger magnitude when capacity is less sufficient.

As shown in Figure 5.11, when there is SIS, RTC was the lowest when CT is Low, increased slightly when CT changed to Mid, and then increased a little faster when CT became High; when there is no SIS, RTC increased gently when CT moved from Low to High. The cost saving reached the highest when CT is Mid and the lowest when CT is High. Figure 5.12 displays the variations of service level across three capacity tightness levels. We can see that the pattern of service level improvement is similar to the pattern of cost savings.

These observations can be explained as follows. Under SIT, backorders are more likely to appear at later periods, and demand is lower than capacity at earlier periods. If capacity tightness is low or moderate, retailers have more chances to move orders at later periods as earlier as possible based on the supply information from the manufacturer. If capacity tightness is high, this order plan revision is highly likely to be impossible. Therefore, the cost saving and service level were improved to a larger extent under low and moderate capacity tightness.

Based on the above observations, the impact of capacity tightness on the value of supply information sharing is significantly influenced by different demand patterns. Overall, these results support hypothesis 4.

**6 CONCLUSIONS**

Analyses of the simulation output reveal the following important findings.

1) Supply information sharing can significantly reduce the total cost and enhance the service level of the whole supply chain. It causes more cost reduction for the downstream part of the supply chain than for the upstream one.

2) The value of supply information sharing is significantly influenced by demand patterns. Supply information sharing brings more supply chain performance improvement when retailers face demand pattern SEA and SIT than when they face demand pattern SDT.

3) Capacity tightness constrains the potential maximum supply capability of the manufacturer. As expected, capacity tightness greatly influences the value of supply information sharing. The decrease in excess capacity has a positive impact on cost saving and service level improvement. However, caution must be taken in that a manufacturer can adjust its capacity in the long term or for strategic purposes. In this case, the current observation may not be true.

4) There is a significant interaction between demand patterns and capacity tightness. When capacity becomes tighter, SDT and SIT perform worse than SEA. Demand patterns moderate the impact of capacity tightness on the value of supply information sharing. When DP=SDT or SIT, backorders are more likely to appear at earlier periods or at later periods, and supply information sharing plays a larger role when CT=Low and Mid. When DP=SEA, however, backorders may appear at any periods. The strategy of moving backwards based on supply information can always work even though capacity becomes tighter.

The research on supply information sharing remains in its infancy. The following are some limitations and the possible direction of future research:

1)
manufacturer in the supply chain model decides when and how many to produce through MPS. MPS is determined by planning horizon, frozen interval, and replanning interval. These parameters should have an impact on the supply capability of the manufacturer. Therefore, a study investigating the effect of these parameters on the value of supply information sharing is much needed.

2) The cost structure of a supply chain should have significant influence on the simulation results. Therefore, a possible extension of this research could be an investigation of the impact of different cost structures on the value of supply information sharing.

3) For strategic purpose, a supply chain member could adjust its capacity in the long run. For operational purpose, a company can also change its capacity by overtime or layoff in the short term. In this study, we assumed that capacity is constant during all simulation periods. Therefore, one interesting future research direction is to investigate the influence of non-constant capacity on supply information sharing.

REFERENCES


INFORMATION SHARING IN A HIGH UNCERTAINTY ENVIRONMENT: LESSONS FROM CASE STUDIES IN THE DIVERGENT DIFFERENTIATION SUPPLY CHAIN

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ABSTRACT

Information distortion and incapability of sharing information simultaneously between the production sides and demand sides make the major uncertainty of the supply chain. This study tends to understand how to share information effectively in a high uncertainty environment based on case studies on three Printed Circuit Board (PCB) companies in the divergent differentiation supply chain, in Taiwan. The results show that PCB industry is with high uncertainties across the demand, manufacturer, and distribution sides. Trust can increase information sharing while risk is considered the main factor impeding information sharing. Information sharing content through the sharing of “demand forecast information” can improve the OFP’s performance. Furthermore, information sharing with VMI mechanisms can reduce supply chain uncertainty, especially in the divergent differentiation supply chains. The inter-organizational coordination can be coordinated through the VMI system to reduce the bullwhip effect and risks.

Keywords: Information sharing, uncertainty, VMI, coordination, trust.

INTRODUCTION

The supply chain is a complex network, and it is even difficult to analyze [9]. Among the supply chain issues, uncertainty and information sharing are common research topics [7] [16]. Uncertainty is one of the crucial issues discussed frequently in the supply chain management [4] [10] [14]. Davis pointed out that numerous factors in a complex Supply Chain Network (SCN) can cause uncertainty, and any factor has the potential to affect the whole supply chain network, especially the efficiency [4]. Seeking an effective management on the supply chain requires companies to identify what uncertainty factors are, and then try to minimize consequent results and impacts. The so-called “Bullwhip Effect” is considered as one of the major factors that cause the uncertainty among supply chain nodes. This is mainly resulted from information distortion and incapability of sharing information simultaneously between the production sides and demand sides of each node connection in a supply chain, and in term reduces the overall supply chain performance.

Strader et al. argued that it is almost impossible to eradicate all uncertainty factors, yet the impact made from them can be reduced when proper managerial strategies are in place. Information sharing is one of them [22]. According to Tan et al., information sharing can reduce uncertainty factors, and increase the efficiency of a supply chain [23]. Information sharing aims to capture and disseminate timely and relevant information for decision makers to plan and control supply chain operations [21] [25]. Strader et al. believed that effective information sharing can reduce the errors made during the decision making processes in supply chains, and therefore enables a proper control on the uncertainty factors, so that the business risk can be reduced [22]. In addition, exchanging information between supply chain partners can lead to operational efficiencies and new knowledge creation in supply chains, even when learning from partners may not be an explicit goal [18].

Although sharing information is advantageous, it is a difficult task in a supply chain due to several challenges. Lee and Whang revealed that sharing information in a supply chain needs to overcome several challenges lying in the implementation, e.g. lack of willingness of sharing sensitive information among different partners; information confidentiality issues; how to share the cost and risk of implementing information equipments required for achieving information sharing; and how to improve the negotiation and planning activities within a supply chain in order to achieve the goal of information sharing [15]. Apart from that, the challenges faced from the execution of information sharing (such as the profit distribution issues regarding information sharing) also make enterprises feel intimidated of sharing. For certain supply chain members, information sharing does not necessarily bring positive results for their business profits, and might even incur more operating costs. This is the reason which causes these supply chain members showing a lower willingness to share sensitive information such as cost, productivity and pricing information, or causes them to use the these types of sensitive information as a bargaining chip when negotiating the distribution of profits. Therefore, how to evenly distribute the profits and possible risks resulted from information sharing is an important consideration for determining whether a long-term cooperative relationship is maintained among these supply chain members.

Several kinds of models have been used to assist in the analysis of supply chain related strategies. For example, push and pull model is used when focusing on the analysis of production and replenishment of inventory management related issues [24]. The replenishment in the push strategy is based on the forecast whereas the actual consumption volume is the focal point in the pull strategy. Make to Order (MTO) and Make to Stock (MTS) models are used for discussing production strategies in the relationships between customers and suppliers [1]. However, most previous models pay more attentions to the dyadic parties in the whole supply chain including the sender and receiver. Lin and Shaw suggested another model which includes three types of supply chain, and it is more appropriate to oversee the issues across the entire supply chain form the upstream to the midstream and downstream [17]. Among the three types, Divergent Differentiation Supply Chain is with the highest uncertainty, and is more challenging to manage. Relatively, fewer studies focus on the divergent differentiation supply chain. Due to
these characteristics, this study has chosen divergent Differentiation Supply Chain for research object. Most of the past studies on information sharing in the divergent differentiation supply chain are based on simulations method (e.g., [22] [26]), and the study on real world situation of the supply chain is demanded. This study tends to fill this gap by performing three case studies on three Printed Circuit Board (PCB) companies PCB industry, a type of divergent differentiation supply chain, in Taiwan. This study particularly aims at understanding the following questions: first, how organizations deal with the uncertainty in divergent differentiation supply chains through information sharing; second, whether the supply chain uncertainty can be reduced through cross-organizational coordination and the content of information sharing; and third, what key factors affect them to perform information sharing.

The rest of the paper is organized as follows. The next section describes the supply chain types, factors causing uncertainty, and factors that affect information sharing in a supply chain. Then, a framework of four main dimensions and nine variables is discussed as well as the research designs. After that, case results of studying three PCB manufacturers are supplied that also include the cross cases comparison and research Lessons. Finally, the conclusion, limitations, and future research are presented.

THEORETICAL BACKGRAUDNS

Supply Chain Types

A supply chain network is mainly comprised of a series of autonomous and semi-autonomous organizational entities from upstream to downstream, interconnected to fulfill the order request from customer through various processes and activities [3] [14] [17]. In terms of product demand, Fisher divided products into functional and innovative types [6]. The demand on functional products is more stable, and it is required efficient supply chain strategies to reduce inventory accumulations in the overall channel. In contrast, the market of innovative products is faced with unpredictable changes in demand, and need to adopt the supply chain strategies that can rapidly respond to the market so as to seize profit opportunities in the early stages of the product lifecycle. Lamming et al. revised Fisher’s categorization and suggested two dimensions to define the types of supply network – the characteristics and complexity of the final products [6] [12]. According to Lamming et al., the characteristics of products can be divided into two categories – innovative-unique and functional depending on the innovation degree of the product, while the product complexity can be categorized based on the sensitivity of the technology used for product manufacturer and the number of the components used in the product [12]. For innovative-unique products with high and low complexities, the key for supply chain development is on the speed of product development, productive elasticity, innovation degree and quality control. For a functional product with high complexity, the key for supply chain development lies in reducing manufacturer costs and enhancing the service quality. For a functional product with low complexity, the key for supply chain development lies in reducing manufacturer costs through mass production, and enhancing the service quality.

In terms of product manufacturer, Lin and Shaw divided supply chain structures into three types - Convergent Assembly, Divergent Assembly and Divergent Differentiation - according to the attributes of manufacturer processes, business objectives, product segmentations, product categories, assembly processes, product lifecycles, inventory categories and so on. As far as convergent assembly supply chains are concerned, the products from this type of networked organizations are comprised of numerous components, and the final products are established through many steps of assembly. Since different components might comes from different suppliers, convergent assembly supply chains may have numerous suppliers. In addition, products of this type are difficult to modify even in the early stages of the product life cycle due to the differences between each part, and hence more difficulties to satisfy specific requirements from customers. For this type of products, the greatest uncertainty is in market demands, and the major inventory cost is from final products. Therefore, the key for convergent assembly supply chain networks lies in the synchronization of the arrival of each raw material, which can reduce inventory and transaction costs as well as increase order fulfillment rate. Typical industries belonging to this category include the automotive industry and the airline industry [17].

As far as divergent assembly supply chains are concerned, the networked organizations of this type usually have their own final assembly factories and distribution systems. To fulfill a high volume of order requests that demand customization, these networked organizations usually turn to delayed differentiation to divide their product assembly processes into two stages: complex semi-finished products are assembled in factories, and easier customized assembly processes are later completed at distribution centers. In addition, since the raw materials required by their products possess the feature of generalization, these raw materials can become parts for different products, and can be assembled into numerous different products through different production lines. This is also the very feature that makes semi-finished products become their major inventories. Therefore, the key for divergent assembly supply chain networks lies in the rapid delivery of products which can meet special requirements from customers, or in other words, shortening the lead time of customized assembly. Typical industries belonging to this category include the PC, mobile phone and other related electronic equipment industries [3] [17].

As far as Divergent Differentiation supply chains are concerned; the final products of this type are usually finished goods before the customers place their purchase orders. This feature often results in late response or oversupply to customer demands from the overall supply chain due to inaccurate forecast of the demand information, and might generate other issues such as high rates of inventory accumulations, overstocking of capitals, or purchasing order transfers to other suppliers. According to this feature, the networked organizations of this type usually have their own final assembly factories and distribution systems. In addition, due to a great variation in product specifications, the life cycles for products can be as short as a few months, or even just a few weeks. Therefore, the differences for products mainly come from manufacturer factories, and hence the
ability to respond rapidly has become a key factor for this type of supply-chain organizations. Typical industries belonging to this category include the clothing industry and the toy industry [17].

Based on the three different supply chain types and their respective objectives, Lin and Shaw proposed corresponding information sharing contents for each supply chain type [17], as can be seen in Table 1.

Table 1. Supply chain types and information sharing strategies

<table>
<thead>
<tr>
<th>Manufacturing Procedures</th>
<th>Convergent Assembly</th>
<th>Divergent Assembly</th>
<th>Divergent Differentiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Chain Goals</td>
<td>Lean production-to supply goods with the lowest possible costs</td>
<td>Customization-to supply customized goods to customers</td>
<td>Agile production to instantly supply products that can meet market demands</td>
</tr>
<tr>
<td>Information Sharing Contents</td>
<td>Productivity negotiation and planning</td>
<td>Demand and ordering information</td>
<td>Market demands</td>
</tr>
<tr>
<td></td>
<td>Inventory changes</td>
<td>Customer ordering quantity</td>
<td>Customer sales</td>
</tr>
<tr>
<td></td>
<td>Production schedules</td>
<td></td>
<td>Customer responses</td>
</tr>
</tbody>
</table>

In line with above discussions, it is suggested that there are great differences between the supply chain structures of different industries, and the supply chain structures may have impact on their relevant information sharing contents.

Factors Cause Uncertainty

The most important issue of supply chain management is to comprehend and manage the uncertainty factors of a supply chain in order to alleviate their influences. From the viewpoint of the interactions between upstream and downstream vendors in a supply chain, Davis concluded that the uncertainty factors from three dimensions - demand, supply and manufacture - are the major reasons that cause the delay of the final product delivery date or the degradation of customer service level [4]. If uncertainty-related information with respect to these three dimensions can be obtained more, their influences can then be understood better. Each of these factors is elaborated as below:

1. First, uncertainty factors in demand: the average demand and the demand variations should be evaluated. Second, uncertainty factors in supply: the punctual delivery rate, average delay time and delay time variations of suppliers as well as the quality of their delivered goods should be evaluated. Third, uncertainty factors in manufacturer: information needing evaluation include downtime frequency, repair time, repair time variations, reliability of the manufacturing process, etc.

When investigating supply chain uncertainty, Lee and Billington also divided it into the same three dimensions - supply, manufacturer, and demand and considered the sources of supply chain uncertainty as: (1) supplier lead time and delivery performances; (2) feedback quality in the future; (3) manufacturer process time; (4) delivery time, and (5) demand [13] [14].

Based on above discussions, this research agrees that the uncertainty factors involved in the operation of supply chain processes can be divided into three dimensions, i.e. demand, supply and manufacturer.

Factors Affect Information Sharing

Researchers who investigated inter-organizational partnerships tended to utilize characteristics like trust, commitment, and power to describe the relationships and phenomena between organizations. According to Morgan and Hunt, trust and commitment are two important factors for the successful maintenance of a long-term partner relationship. The stronger the mutual trust is the more reassured the partners will be when cooperating with each other. Commitment means partners are consistently investing a certain amount of resources, and are showing willingness of continual cooperation. The stronger the mutual trust and commitment between partners are, the more the uncertainty of cooperation can be reduced, and the better the coordination between partners can become [20]. Anderson and Narus defined trust as “the belief of a vendor that its cooperative vendors will take actions in favor of its interests, or at least will not take actions against it” [2]. According to Morgan and Hunt [20], trust happens when a group has confidence in the reliability and morality of its trading partners, has faith in the authenticity of words and promises from its members, and believes its members will fulfill their duties in this trading relationship. Mayer et al. points out that trust are composed of three dimensions: Ability, Good will and Honesty [19].

Inter-organizational coordination and information sharing are necessary and beneficial for a business seeking growth. However, the negotiations between different parties are usually hindered by various obstructions which might in the end cause the failure of inter-organizational coordination and information sharing. Besides, different organizations may have different goals, cultures, operation processes, risk considerations, demands and willingness of cooperation and these may all become factors that can have impact on inter-organizational coordination and information sharing in addition to the technological aspect. Lee and Whang pointed out that information sharing in a supply chain is faced with several challenges lying in its implementation, e.g. lack of willingness of different partners to share sensitive information with each other, information confidentiality issues, how to pool the cost and risk of implementing information equipments required for achieving information sharing, as well as how to improve the negotiation and planning within a supply chain through information sharing so as to achieve the goal of information sharing [15].

When considering the risk of information sharing, Kumar and Dissel divided the risk of inter-organizational information sharing into three aspects: first, economic aspect: inter-organizational information cooperation can help participants to share huge investment amounts, to increase their resource utilization rates, to reduce supply-chain uncertainty, and to increase their economic scales. However, from a practical standpoint, the results depend upon whether this kind of cooperative relationship can last long, and whether each participant can always be aware of the fairness and benefit of their cooperation. Second, technical aspect: Information and communication technologies have been generally acknowledged as inter-organizational enablers. On the contrary, lack of a stable, mature and reliable technology connection will also hinder and suppress inter-organizational connections. Third, socio-political aspect:
Inter-organizational cooperation may be established through some strategies or negotiations [11]. But this cooperative relationship can be breached by some socio-political factors, such as researching for new advantages, conflicts in execution, different cultures and values between different organizations. Concluding the above discussion on the three aspects, this research will lay emphasis on the economic and technical aspects proposed by Kumar and Dissel [11], and will temporarily disregard the socio-political aspect since it is more difficult for an organization to control, comprehend or effectively handle on its own.

Research Designs

This research has chosen the PCB industry, the industry with high uncertainty, to investigate information sharing issues and supply chain uncertainty factors. Since PCBs are critical parts for consumer electronic products, PCB manufacturer factories are in the upstream of the whole product supply chains and are distant from the consumer market. Most PCB manufacturer factories are OEMs, so they receive orders from various final-product manufacturers or contract assembly factories. However, each PCB manufacturer factory has different product structures and customer groups. A preliminary study on the PCB industry showed that the communication boards (mobile phone boards) are their major products. Since the functions of communication products are renovated frequently, the product life cycles of the communication boards used to implement these functions are shortened accordingly. Nowadays, mobile phones are gradually transforming from communication electronic products into consumer electronic products, mobile phone boards have even shorter life cycles, facing customer revision or cease or production in no longer than 6 months. In addition, since the demand for the final products in the mobile phone market are more unstable and more difficult to predict, it is common for customers seeking optimal product launch times to change their ordered quantities or delivery dates. The production plans of the PCB manufacturer factories will be jointly affected by the customers’ changes in demand, so the production schedules have to respond instantly. Therefore, innovative products contribute a very high percentage to the PCB industry, which contains numerous uncertainty factors. To avoid the possibility of being biased by single case design, this research adopts a multiple case design with embedded multiple units of analysis. This research chose three of the top ten PCB manufacturer factories as studying cases. All of them belong to supply chain networks categorized as divergent differentiation supply chain, and their customer-end products are mostly communication electronic products. They have passed ISO 9002, ISO 14000, QS 9000 certification, capitals range from NT 4 to 6 billion or so, and are listed in the stock market. Their characteristics are listed in Table 2.

Table 2. Characteristics of case companies

<table>
<thead>
<tr>
<th>Focal Companies</th>
<th>PCB Manufacturer Factory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profit Sources</td>
<td>Foreign major communication companies</td>
</tr>
<tr>
<td>Life cycles for Final Products</td>
<td>6-12 months on average</td>
</tr>
</tbody>
</table>

The chosen interviewees are the directors of procurement, sales, production, manufacturer, and information departments. Moreover, the information sharing issues to be investigated include not only general trading information, but also higher-level management information. The data gathered by this research are mainly through face-to-face interviews, supplied with other documents and related archives (from internal reports of the case companies, newspapers/magazines and seminar data). For the triangulation purpose, this research adopts the method of multiple data source analysis. This research has tried to include as many data sources as possible in order to ensure the accuracy of the information obtained. This research designed its data collection items and interview guides based on the issues to be investigated, and sorted the issues out in advance to serve as a reference for data collection in order to ensure the data collected is relevant. In addition, the interviewers took notes during the interviews for further analysis. The analysis results generate seven major useful lessons.

With the aim to investigate issues relating to information sharing, this research needs to gain a perspective that can view a supply chain as a whole so as to discover where the problems are. Therefore, this research takes the whole supply chain as its main unit of analysis. This study uses four main dimensions and nine variables to study more complicated and detailed relationships between the variables and how to reduce the uncertainty generated, as can be seen in Table 3.

Table 3. Analysis dimensions and variables

<table>
<thead>
<tr>
<th>Analysis Dimension</th>
<th>Analysis Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Chain Uncertainty</td>
<td>Demand side</td>
</tr>
<tr>
<td>Information Sharing</td>
<td>Inter-organizational coordination</td>
</tr>
<tr>
<td>Information Sharing Factors</td>
<td>Trust</td>
</tr>
<tr>
<td>Supply Chain Performance</td>
<td>Effectiveness assess</td>
</tr>
</tbody>
</table>

This study approached managers from the departments of sales, procurement, production control, and IT, and sought information about the interactions with suppliers and customers as well as detailed information about the decision making of senior management. To ensure collecting reliable data, face-to-face interviews were employed as primary method for data collection while company documents were used to provide supplementary information and triangulate the final analyses.
CASE STUDY RESULTS
Organizational Context of the Three Cases

Company A, the large printed circuit board (PCB) manufacturer, was established in 1979 and its current annual turnover is approximately 5.1 billion Taiwan dollars. Its products are used by a wide range of electronic products, but the major focus is on consumer electronics, telecommunication electronics, and electronics in cars. Company B, also the large PCB manufacturer, was established in 1974 with the capital of 4.6 billion Taiwan dollars. The main product categories are electronics in cars and telecommunication electronics. Company C is the third large PCB manufacturer, and its current annual turnover is approximately 5.7 billion Taiwan dollars. Most of its products are main board in mobile phones and the liquid crystal display (LCD). Organizational context of the three cases are presented in Table 4.

Table 4. The cases backgrounds

<table>
<thead>
<tr>
<th>Backgrounds</th>
<th>Manufacturer Company A</th>
<th>Manufacturer Company B</th>
<th>Manufacturer Company C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year Established</td>
<td>1979</td>
<td>1974</td>
<td>1978</td>
</tr>
<tr>
<td>Annual Turnover (Billion NT)</td>
<td>5.1</td>
<td>4.6</td>
<td>5.7</td>
</tr>
<tr>
<td>Product Portfolios</td>
<td>Communicator boards (&gt;50%); Consumer electronic boards</td>
<td>Mobil phone boards (50%); Automobile part boards</td>
<td>Mobil phone boards (50%); LCD boards</td>
</tr>
</tbody>
</table>

Comparison of Cases A, B, C

The supply chain of PCB industry is categorized as divergent differentiation supply chains. The three cases are the manufacturers of consumer products, automotive electronics and communications category mostly covers a wide range, including: air conditioning, TV, refrigerator, phone, telephone, car panels, LCD board, network board, the base station board printed circuit board. The electronic products have the characteristics of diversified product ranges, short product life cycles, and unpredictable demands. In addition, PCB manufacturers are mostly recognized as OEM. Yet, the circuit designs of products requested by customers are highly customized and contain various levels of diversification, and such diversification of product designs makes each kind of plastic board has its unique specification and cannot be used by other customers. To deal with the high uncertainty, presently, PCB manufacturer factories are adopting the MTO approach to speed up their order fulfillment processes by utilizing the demand forecast information shared by their customers to map out their productivity and raw material demands in advance. Furthermore, the PCB cases performed information sharing activities in their SCM processes accompanied with VMI mechanisms. The information sharing initiatives and VMI mechanisms of the three cases are presented in Table 5.

Table 5. The information sharing initiatives and VMI mechanisms of the three cases

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Manufacturer Company A</th>
<th>Manufacturer Company B</th>
<th>Manufacturer Company C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information Shared</td>
<td>Information of transactions, demand forecast, and stock.</td>
<td>Information of transactions, demand forecast, and demand forecast of raw materials.</td>
<td>Information of transactions, demand forecast, and products outflow.</td>
</tr>
<tr>
<td>Information Sharing Practices</td>
<td>1. Give more trust to the customers who use VMI. 2. Perform more inter-organizational coordination and data exchanges with the customers who use VMI. 3. Most information sharing practices are to satisfy basic level transactions, and less to perform strategic thinking. 4. The intention to share only depends on the needs of customers and suppliers. 5. Sharing sensitive information is restricted.</td>
<td>1. Establish VMI warehouses 2. Supply stocks for customers based on the demand given by them. 3. Rent VMI warehouses 4. Develop production plans based on demand forecasts</td>
<td>1. Rent VMI warehouses 2. Supply stocks for customers based on the orders placed by them.</td>
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</table>

This study found that the uncertainty of the divergent differentiation supply chain of PCB industry is mainly from demand and manufacturer sides. Dealing with the orders placed by customers is critical, especially the ways to increase customer satisfaction on the orders effectively, such as ensuring the just in time (JIT) practices, and ensuring high product quality. The case companies adopted the approach of sharing order and manufacturer information which means letting customers check the status of the production of their orders, product delivery, and yield rate in order to enhance customer service quality and reduce product return rate. Moreover, in the divergent differentiation supply chain of PCB industry, sharing order and manufacturer information with their customers can also improve the efficiency of order fulfillment.

In terms of the degree of information sharing, the case results show that the requirements posed by supply chain partners will determine what to share and to what extent. The parties in the chain try hardly to gain a mutual trust in order to exchange information. Also, the willingness of sharing information between partners depends on the risk of sharing the particular information and whether the information will affect the bargaining and negotiation powers. Furthermore, due to the
concern of organizational secret and interests, the companies tend not to share information that will let their customers know the production techniques, yield rate, materials stock, and production costs. Apart from sharing information to reduce uncertainty, PCB manufacturers also adopt VMI mechanisms in the sharing practices to maintain minimum level of stocks and ensure the effectiveness of information sharing. Most of the cases, they try their best to obtain the latest stock information from customers and provide update information on order fulfillment process in order to ensure the accurate demand for helping perform demand forecast and carry out production plans. The use of VMI mechanisms allows customers to modify their orders so that the risks of being out of stock on raw materials and holding excessive stocks can be reduced. Thus, this study found that the use of VMI mechanisms in information sharing practices in the divergent differentiation supply chain can improve the coordination and reduce the bullwhip effect.

LESSONS LEARNED

Based the viewpoint of coping with uncertainty issues, this research has utilized case study method to investigate the uncertainty factors that might exist in the demand, supply and manufacturer dimensions and how manufacturer factories should manage and adapt to these uncertainty factors through information sharing, as well as the key factors that might have impact on information sharing between partners. Through the above investigations, this research deduced seven I.

Lesson 1

The uncertainty in the divergent differentiation supply chain is largely originated from the demand and manufacturer sides due to the features of simple raw materials, highly-customized products, and shorter product life cycles. Due to a wide range of product categories, PCB manufacturer factories frequently receive the contract orders for producing the products that are highly diversified, have short life cycles, have demands which are difficult to predict, and they need to incorporate product design changes frequently. Based on the viewpoint of product manufacturer, PCBs do not require many kinds of raw materials, and the product differentiation occurs in the early stages of the manufacturer process. Based on these characteristics, this research deems that most PCB manufacturer factories belong to divergent differentiation supply chain networks [17]. The case analysis results also show that most of the factors that can result in the manufacturer uncertainty of a divergent differentiation supply chain are caused by the instability of the demand and manufacturer side. For example, the changes in demand (such as unexpected orders) can result in schedule disorder accordingly.

Lesson 2

In a divergent differentiation supply chain, sharing information with the demand side helps improve the performances of the order fulfillment process (OFP). Products from the PCB manufacturer factories are mostly innovative products. Their supply chain strategies mainly focus on timeliness so as to rapidly respond to the market demands [6]. Time to market is the most critical factor for attaining this goal. Therefore, PCB manufacturer factories, most of which belong to divergent differentiation supply chains, focus more on how to cope with the dynamic demands from the downstream customers, and how to enhance their on-time delivery fulfillment rates. To supply products which can meet customer requirements while keeping their inventory at the lowest level, PCB manufacturer factories tend to adopt the MTO approach, or in other words, to manufacture according to the contents and specifications of the orders placed by their customers. Through the sharing of product demand forecast, PCB manufacturer factories can map out the demands for raw materials, production plans, and even their productivity in advance, because the enhancement of information transparency can facilitate the execution of production and management decisions, shorten the order processing time of the MTO approach, and therefore improve the OFP performances.

Lesson 3

The supply chain uncertainty can be reduced through inter-organizational coordination. Inter-organizational coordination between organizations can reduce the costs of information search and coordination, reduce organizational uncertainty, shorten delivery time, and control strategic market information. Due to the frequent customization of PCB products, PCB manufacturers are adopting MTO production strategies and maintaining minimum inventory cost while achieving the diverse needs from customers. Furthermore, the differentiation on PCB products occurs in the early stage of production process. Thus, the demand uncertainty derived from requirement changes can be reduced through signing agreements with customers to secure that customers can cover the costs of raw materials for unfinished products in a certain period of time. The case results show if the actual order amount is much larger than demand forecast, the manufacturer will coordinate with the customer to delay the delivery date in order to give more time for the supplier to prepare extra raw materials for supply. Such coordination can reduce the effect caused from demand change greatly. In addition, to reduce the uncertainty of lead time when purchasing special raw materials is needed, the manufacturer coordinates with the customer, if possible, to replace substitutitive materials or to provide demand forecast of the product earlier.

Lesson 4

In a divergent differentiation supply chain, sharing information through the VMI mechanism helps improve supply chain coordination and reduce the bullwhip effect. Even if information sharing is conducted, most of the forecast information may become inaccurate when the changes in demands grow too large. Thus, simply conducting information sharing is of no great help to the reduction of the bullwhip effect [8]. This research found that the studied PCB manufacturer factories have established Vendor Managed Inventory (VMI) mechanisms with their customers. Therefore, through efficient sharing of inventory information, PCB manufacturer factories are able to adjust their supply
according to the actual demand from the customers so as to reduce the chance of oversupply or under-supply. Meanwhile, customers can use the inventory information as a reference to clear their orders or to modify their demand forecast information. Therefore, this research deems that information sharing can facilitate the establishment of a inter-organizational coordination mechanism, and also reduce the significant impact that the bullwhip effect might bring to upstream suppliers.

Lesson 5
The stronger the trust between partners is, the higher the level of their information sharing will be.

Between the three PCB manufacturer factories and the customers who have created higher degree of trust with them, the information shared include not only their transactions information, but also the demand forecast and inventory information. When the suppliers have acquired higher degree of trust with these three PCB manufacturer factories, these factories are more willing to share information that can assist these suppliers in making production decisions, such as the latest market information. We also found that the three PCB manufacturer factories have more trust toward their VMI customers. Nevertheless, the trust from these PCB manufacturer factories toward their supply chain partners only emerges after a long period of cooperation. During the long-term cooperation, the PCB manufacturer factories were constantly observing and evaluating whether their customers can provide stable orders and exhibit positive trading behaviors, and whether their suppliers can display trustworthy delivery performances, so as to establish strong trust with them. This research confirmed that the higher the degree of information sharing is, the more enhanced the trust between them will become, bringing them into a benign cycle.

Lesson 6
The willingness of information sharing will be affected when organizations are driven by risk considerations and use information as a bargaining chip.

This research found that the motivations that drive the three PCB manufacturer factories to share information with their partners are mainly operational rather than strategic. In other words, they are only willing to provide information that is required by their partners, and tend not to share the more sensitive information (such as process yields, procurement distribution percentages, etc.) with their partners. The reason that causes these situations in the PCB industry is that downstream customers tend to rely on several suppliers to be their supply sources, so the chances for them to develop strategic partner relationships are slim. Therefore, in the PCB industry where cost is the most important competitive advantage, companies are unwilling to share with their customers the process yield information which is indirectly related to their costs, or other information related to their business confidentiality, such as the WIP (Work in Process) or the contractor productivity distribution information. This is because these PCB companies worry that once they share their internal procurement and bargaining information with their customers, their dominant position in the bargaining process may be deprived.

Lesson 7
Once inter-organizational coordination mechanisms are established, sharing information through the use of VMI can effectively disperse risks.
The PCB customers tend to maintain appropriate amount of stock when supplying products to the market. In order to prevent the loss caused from short supply or over supply, the VMI mechanism is built between the manufacturer and customer. Both parties also agree to share necessary information in the coordination process and disperse risks through such information sharing practices. Based on the case results, when the channel of sharing stock information is established and the coordination mechanism is functioning, PCB manufacturers can reduce the cases of short supply or over supply. Both parties can therefore reduce the risks in the transactions.

CONCLUSION

This study investigated how information sharing can reduce the uncertainty in the divergent differentiation supply chain and increase supply chain performance. The critical factors that affect information sharing are also extracted. This study found that in a divergent differentiation supply chain, the stronger the trust between partners is, the higher the level of their information sharing will be. Based on inter-organizational coordination mechanisms, sharing information through the use of VMI can effectively disperse risks, help improve supply chain coordination, reduce the bullwhip effect, and improve the performances of OFP. The supply chain uncertainty can be reduced through inter-organizational coordination. The research results are summarized as Figure 1, and more elaboration of the figure are provided afterward.

Figure 1. Research results of this study.

This research found that trust and uncertainty are two key factors that might stimulate information sharing. Currently, most relationships between PCB manufacturers and their upstream and downstream partners are still in a type of general transaction relationships. Due to risk considerations, organizations tend not to share sensitive information that they can use as bargaining chips. Through the sharing of product demand forecast, however, PCB manufacturers can map out the demands of raw materials, production plans, and even their productivity in advance, because the increased information transparency can facilitate the execution of production and management decisions, shorten the order fulfillment time in the MTO approach, and therefore improve the efficiency of OFP.

Bullwhip Effect refers to the scenario where the orders to the
supplier tend to have larger fluctuations than sales to the buyer, and the distortion propagates upstream in an amplified form [5]. If the customers are providing their demand information only in the form of orders, these PCB manufacturers are more likely to be affected by the bullwhip effect. However, through VMI approaches, the PCB manufacturer factories and their customers are able to establish more effective information sharing and inter-organizational coordination mechanisms that will assist in dealing with negotiation activities (e.g. on prices and specifications), product design revision, and order change in a timely basis. The bullwhip effect can therefore be reduced.

Limitations and Future research

This research has committed to bridge the gap between theory and practice. However, no different to others, this research still has its limitations. There are three limitations; first, the PCB industry is a rapidly-changing environment. Therefore, different data collection time points may yield different results which may influence the analysis of a PCB supply chain's current status. Second, during the process of data collection, the knowledge backgrounds of the interviewees may have impact on their understanding of the interview questions. Third, this research only selected three manufacturer factories as the PCB industry’s individual cases. However, the main objective of this research is not to generalize, but to investigate and comprehend the PCB industry's current status. Therefore, the conclusions of this research may provide a foundation for further verification by subsequent researchers. Below are three future research directions: first, the objects investigated by this research are limited to PCB vendors. However, the demand for IC package substrates is also booming in recent years. Therefore, the IC package substrate industry may also be worthy of subsequent researches. Second, for the present, upward or downward integration is rarely seen in the PCB industry. However, if any trends of vertical integration or strategic alliance emerge in the future, the demand, supply and manufacturer uncertainty factors of PCB supply chains will have to be reexamined then. Third, this research is based on a small number of cases only. Thus, the generalization of its lessons may be limited. Future researchers can statistically test these lessons through a larger sample base.

REFERENCES


TRADEOFFS IN DECISION MAKING: A SHIPPING CHOICE EXAMPLE

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ABSTRACT
Decision makers often struggle with balancing the short-term gain and the long-term benefit. In bulk transport, carriers face a shipping choice problem, either as a conveyance shipping high-value goods (HVG) with high freight but uncertain supply, or as a newsvendor shipping low-value goods (LVG) subjected to demand uncertainty. We investigate the shipping choice under various situations based on the tradeoff analysis on each choice. The shipping choice and the associated waiting-time decision illustrate the tradeoff between the short-term profit and the long-term benefit in decision making.

Keywords: decision making, bulk transport, newsvendor, martingale model of forecast evolution, Bayesian updating

I. INTRODUCTION
Decision making in the real world means making tradeoffs based on the best information available. A typical tradeoff is between the short-term interest and the long-term benefit. For instance, in the area of investment, decision makers need to decide whether investing in assets with certain but low returns or waiting for the opportunities with high but uncertain payoffs. In the area of human capital development, the choice can be investing in raising existing workers' capabilities for long-term competitiveness or harvesting the short-term gains by cost-cutting measures like retrenchment. In the area of productivity, the choice can be building foundations to improve the firm's productivity through sustaining capabilities or focusing on quick fixes which guarantee no future.

To make a wise choice, decision makers need to balance the short-term interest and long-term benefit inherent in each choice. The cost and benefit associated with a choice depend on the specific management decision and situation. In this paper, we focus on a concrete choice problem in operations management, specifically, the shipping choice faced by a carrier in bulk transport under various situations. We consider the shipping choice problem both in a single-period situation and multiple-period situation. In a single-period situation, we concentrate on the one-time shipping choice between two goods, specifically, one with high profit and supply uncertainty v.s. the other with low profit and demand uncertainty. In a multiple-period situation where several shipping choices are made, we concentrate on the waiting-time decision in each period. We aim to investigate what will be the right (if not optimal) shipping decision that balances the short-term interest and long-term profit.

The structure of the paper is organized as follows. In section 2, we briefly introduce the shipping choice problem faced by a carrier in bulk transport. In section 3, we discuss the model and the assumptions used in the paper. In section 4, we focus on the shipping choice due to the supply uncertainty. In section 5, we concentrate on the impact of demand uncertainty on the shipping choice. In section 6, we investigate the shipping choice in terms of the waiting time decision in a multiple-period situation. Summary and managerial insight as well as future research directions are provided in section 7.

II. SHIPPING CHOICE PROBLEM IN BULK TRANSPORT
Bulk transport including ore, coal, cement, chamotte, steel, foodstuff, fertilizer and nonmetal mineral commands a large market share in the shipping industry, especially inland shipping. Bulk cargoes are transported mainly through bulk cargo ships which are designed especially for particular bulk transport. Generally, bulk cargo ships are suitable for shipping a few types of goods with similar characteristics. During each trip, a cargo ship only carries one type of goods most of the time. Due to different characteristics of the goods, for the same distance and the same amount, the profit (or the freight) of each transportation is different depending on the type of goods. In general, the higher the value of the goods is, the higher the profit, in terms of per unit-distance, of the shipping transaction reaps. For example, the freight of steel (per unit-distance) is higher than that of ore. Ideally, the owner of the bulk cargo ship (denoted as the carrier) should choose only the most profitable goods for each shipping transaction. However, the transport demand of a particular goods, i.e., the business opportunity to the carrier, depends not only on the upstream supply but also on the downstream demand. As the shipping demand for different goods differ, the carrier, thus, faces the shipping choice decision that is to ensure the ship is deployed in an efficient and profitable way.

The business opportunities for high-value goods, termed as HVG, are somewhat limited and uncertain. They are limited as HVG with higher profit per unit-distance is preferred by all carriers; they are uncertain as the supply and the demand of HVG fluctuate due to economic cycles. Therefore, the carrier can not always choose to transport HVG when the ship is available. While the business opportunities for low-value goods, termed as LVG, are ample, the carrier can ship the goods whenever available. In short, the business opportunities for LVG are predictable.

The uncertain business opportunities for HVG imply that if the carrier wants to ship HVG for high profit, he may need to wait at the port, which incurs waiting cost. Although the business opportunities of LVG are present, the profit from shipping LVG is relatively small. Therefore, there exists a significant tradeoff between profitability of a shipping choice and the uncertainty of business opportunities, i.e., shipping HVG for high profit with uncertainty v.s. shipping LVG for low profit with certainty.

As the transport cycle is usually long in the shipping industry, ranging from several days in inland shipping to...
several months in ocean shipping, the carrier needs to make a wise choice before committing the shipment. The transaction practices also differ depending on the types of goods. For HVG transport, the cargo is generally used as a conveyance and the carrier collects a fixed amount freight, i.e., the carrier only faces the supply uncertainty of HVG. For LVG transport, the carrier acts as a retailer and he needs to buy the goods at the port of shipment and sell the goods at the destination, i.e., the carrier faces demand uncertainty of LVG. Relative to the complete transport cycle, the selling period of LVG is short. Thus, in the case of shipping LVG, the carrier actually acts as a newsvendor and it is not profitable for the carrier to carry any unsold goods back. Besides the unfulfilled shipping demand of LVG is usually lost due to long transport cycles.

Therefore, this paper intends to evaluate the tradeoff and offer insights on if the carrier should ship HVG or LVG, and when waiting is a wise choice.

III. THE MODEL

Based on the above description, we adopt a simple mathematical model to analyze the shipping choice problem faced by the carrier. The follow notations are used throughout the paper. The capacity of the carrier is denoted as \(K\). The random variables \(x\) on the support \([\bar{x}, \bar{x}]\), where \(\bar{x}\) may be infinity and \(\bar{x} \geq 0\), with probability density function (PDF) and cumulative distribution function (CDF) as \(\phi(\cdot)\) and \(\Phi(\cdot)\) is used to denote the arrival time of the uncertain business opportunity of HVG. The random variable \(D\) with PDF and CDF as \(f(\cdot)\) and \(F(\cdot)\) is used to denote the uncertain demand of LVG. For simplicity, we assume the transport distances of HVG and LVG are the same (while the managerial insight is not affected). If the carrier waits for HVG, the waiting cost is \(C(x)\), which is assumed to be increasing and convex (the convexity can be estimated through the paper). The capacity of the carrier is denoted \(C_x\) per unit. Therefore, the profit of shipping HVG is \(h\) per unit. The unit purchasing cost and the selling price of LVG are \(w\) and \(l\) respectively. The salvage value of unsold LVG is \(s\) per unit and \(s \leq w\). The expected profit of shipping LVG can be solved from the traditional newsvendor model [1] as

\[
\pi_i = \max_{Q \leq K} \{ lE \min(Q, D) + sE(Q - D)^+ - wQ \} = lE \min(Q, D) + sE(Q - D)^+ - wQ_i = lE \min(Q, K) + sE(Q - K)^+ - wQ_i ,
\]

where \(Q_i = \min(Q^*, K)\) and \(Q^*\) is the traditional newsvendor solution, which satisfies

\[
F(Q^*) = \Pr(D \leq Q^*) = \frac{1 - w}{1 - s}.
\]

Comparing the profits of the two shipping choices, if \(\pi_i \geq \pi_h\), the carrier will choose to ship LVG all the times. Therefore, to make the choice of shipping HVG admissible, we assume \(\pi_h \geq \pi_i\). Thus, the profit difference is \(\Delta = \pi_h - \pi_i \geq 0\). While if \(\beta'(\pi_h - C(x)) \geq \pi_i\), where \(\beta\) is the discount factor, the carrier will ship HVG for sure since the profit from shipping HVG in the worst situation is larger. Therefore, we assume \(\pi_h \geq \pi_i \geq \pi_i \beta^{-1} + C(x)\). Since the right hand side is increasing in \(x\), if \(x\) is large enough, the right hand side of the above assumption can be always satisfied. For \(\beta = 1\), i.e., we do not consider the discount effect and the waiting cost is linear as \(C(x) = cx\), where \(c\) is the unit waiting cost, we assume \(\pi_h \leq \pi_h \leq \pi_i + cx\).

We define the strategy in terms of the shipping choice made at the beginning of the horizon (the time when the carrier is ready for transport) in each shipping cycle. There are three strategies, namely two pure strategies and a mixed strategy. The two pure strategies are shipping HVG only and shipping LVG only, denoted as \(H\) and \(L\) respectively for simplicity. The expected profits of strategy \(H\) and \(L\) are denoted as \(\Pi_h\) and \(\Pi_i\) respectively. Clearly,

\[
\Pi_h(x) = \int_{l}^{x}(\pi_h - C(x))f(x)dx , \quad \Pi_i(x) = \pi_i .
\]

The mixed strategy is a threshold policy controlled by a waiting-time decision \(y\), denoted as \(M(y)\), i.e., if the arrival of HVG comes on or before \(y\), the carrier will ship HVG, otherwise ship LVG immediately at time \(y\). Therefore, the expected profit of \(M(y)\) is

\[
\Pi_M(y) = \beta'(\pi_h - C(x))f(x)dx + \int_{l}^{\beta'(\pi_i - C(y))f(x)dx}
\]

Clearly, the two pure strategies are special mixed strategies, i.e., \(\Pi_h = \Pi_M(\bar{x})\) and \(\Pi_i = \Pi_M(0)\). The above formulation is based on the assumption that the carrier knows the arrival distributions of HVG and the demand of LVG, and the shipping choice is made stastically. Thus, under this situation, the carrier concerns about what the optimal shipping choice will be.

The carrier may not know the exact arrival distribution of HVG, and a dynamic shipping strategy will be adopted, where the carrier will ship HVG if it comes or faces an optimal stopping problem, i.e., whether continuing to wait for HVG at the sacrifice of increased waiting cost or shipping LVG immediately. The tradeoff faced by the carrier is between the increased waiting cost and the updated arrival information about HVG. Therefore, the carrier needs to decide the optimal stopping time if HVG has not come yet.

Since the carrier is a newsvendor when shipping LVG, the demand information affects the order quantity. The carrier can update the demand information about LVG when waiting for HVG, or even strategically wait to update the demand information before loading LVG. Therefore, the question is with this capability, what should be a proper shipping decision.

The carrier may not know the exact arrival distribution of HVG, such as the parameter of the distribution. If the carrier has multiple shipping decisions, he can estimate the arrival distribution based on previous experience. Waiting-time decision during each transportation affects the estimation of the arrival distribution. Longer waiting time increase the chances of observing more realizations of the arrival of HVG, which will benefit the future decisions. However, waiting longer decreases the expected profit in
each single transportation. Therefore, the optimal waiting-time decision should balance the tradeoff between the short-term profit and the long-term benefit.

IV. SUPPLY UNCERTAINTY AND SHIPPING CHOICE

In this section, we assume the demand distribution of LVG is static and fixed, i.e., we assume the demand distribution of LVG can be considered as i.i.d variables in every time point, and focus on the one-time choice problem due to the uncertain arrival time of HVG. We first assume the arrival distribution of $X$ is known and derive the conditions for different choices. We then assume the arrival distribution of $X$ is unknown, and a dynamic model is formulated to investigate the characteristic of the shipping decision.

The case with known arrival distribution

We assume a linear waiting cost, i.e., $C(x) = cx$ first. Assume the distribution of $X$ is known with mean and variance as $\mu$ and $\sigma^2$ respectively. Therefore, the expected profit of strategy $H$ is

$$\Pi_H = \int_0^x \beta'(\pi_x - cx) f(x) dx.$$ 

Without discount effect, i.e., $\beta = 1$, the expected profit of strategy $H$ is $\Pi_H = \pi_x - c\mu$, i.e., only the mean of the arrival distribution matters for a risk neutral carrier. Clearly, if $\Pi_H > \Pi_L$, it is optimal to adopt strategy $H$; otherwise, strategy $L$ is a better choice. The expected profit of mixed strategy $M(y)$ is

$$\Pi_M(y) = \int_0^x \beta'(\pi_x - cx) f(x) dx + \int_{x'}^x \beta'(\pi_x - \pi_x) f(x) dx.$$ 

Intuitively, since $\pi_x \geq \pi_1$, there may exists an optimal waiting time where the expected profit of the mixed strategy is larger than any pure strategies. Therefore, it is interesting to see whether there exists an optimal waiting time in the mixed strategy.

To derive the optimal waiting time in the mixed strategy, we take the first order derivative of $\Pi_M(y)$ as

$$\Pi_M'(y) = \beta'(1 - F(y)) G(y)$$

where $\lambda(y) = \frac{f(y)}{1 - F(y)}$ is the failure rate of $X$ at $y$ and $G(y) = \Delta \lambda(y) + (\pi_c - cy) \log \beta - c$.

From the above result, it turns out that the characteristic of the failure rate of the arrival distribution $X$ plays an important role in the choice decision. We have the first order derivative $G(y) = \Delta \lambda(y) - c \log \beta$. We focus on three types of distributions in terms of the failure rate characteristics, namely increasing failure rate (IFR), decreasing failure rate (DFR) and constant failure rate (CFR). The following result summarizes the impact of the failure rate in the shipping choice:

**Proposition 1.** For IFR and CFR distributions, the optimal choice is either strategy $H$ or strategy $L$. For DFR distributions, if $G(x) \geq 0$ and $G(\bar{x}) < 0$, there exists an optimal waiting time $y^*$, where the mixed strategy $M(y^*)$ is optimal.

**Proof:** For IFR distributions, we have $G(y) \geq 0$. Therefore, if $G(y) \geq 0$, $\forall y \in [x, \bar{x}], \Pi_M(y) \geq 0$, the optimal choice is strategy $H$; if $G(y) \leq 0$, $\forall y \in [x, \bar{x}], \Pi_M(y) \leq 0$, the optimal choice is strategy $L$; if $G(x) < 0$ and $G(\bar{x}) > 0$, the optimal choice is the one with higher expected profit, denoted as $\max(\Pi_H, \Pi_L)$. For CFR distributions, $G(y) = -c \log \beta \geq 0$ is constant. Therefore, the situation is the same as IFR distributions. Thus, there is no feasible mixed strategy which is optimal for IFR and CFR distributions.

For DFR distributions, if $\forall y \in [x, \bar{x}], G(y) \geq 0$, the situation is the same as IFR and CFR distributions; if $G(x) \geq 0$ and $G(\bar{x}) < 0$, there exists $y^*$, such that $\Pi_M(y) = 0$ and $\Pi_M(y^*)$ is unimodal, first increasing and then decreasing. Therefore, we can see the existence of an optimal mixed strategy only occurs under DFR distributions.

The critical role of the failure rate is not difficult to understand. The failure rate reflects the conditional probability of the arrival of HVG if it has not come yet. An IFR or CFR distribution means the conditional probability the HVG will arrive increases if it has not come yet. The expression $G(y)$ reflects the potential profit margin of waiting additional time given the condition that the business opportunity of HVG has not come yet at time $y$. Since $\Delta \lambda(y)$ is the potential profit gain of shipping HVG, and $(\pi_c - cy) \log \beta - c$ is the potential loss due to additional waiting. Therefore, if $G(y)$ is always positive, it is profitable to wait for HVG. Otherwise, waiting is dominated by shipping LVG immediately. Under DFR distributions, the potential profit gain of shipping HVG $\Delta \lambda(y)$ will decrease, which may cause the potential profit margin of waiting $G(y)$ to decrease. Therefore, the optimality of mixed strategies only occurs under DFR distributions.

In sum, under IFR and CFR distributions, the carrier only needs to calculate the expected profit of each pure strategy and make the optimal choice; while under DFR, the choice may need further comparisons. There may exist an optimal waiting time, where the mixed strategy is optimal in terms of the expected profit. The following examples are special distributions to illustrate the impact of the failure rate of the arrival distribution on the choice decision.

**Uniform distribution (IFR)** We assume the arrival distribution is uniform in $[0, T]$ with $\lambda(y) = \frac{1}{T - y}$ which is increasing in $y \in [0, T)$. Therefore, we have the expected profit of strategy $H$ as

$$\Pi_H = \frac{(\pi_x + c \log \beta)(\beta^T - 1) - c T \beta^T}{T \log \beta}, \quad \beta \in (0, 1)$$

which is decreasing in $T$, since the first order derivative is
Therefore, if \( \beta = 1 \), there exists a critical value \( T_0 = \frac{\Delta}{c} \), such that if \( T < T_0 \), the optimal choice is strategy \( H \); otherwise, strategy \( L \) is optimal. For \( 0 < \beta < 1 \), using L'Hopital's rule, we have \( \lim_{r \to \infty} \Pi_H = 0 \) and \( \lim_{r \to \infty} \Pi_L = \pi_a \), indicating there exists a critical value \( T^* \), such that if \( T < T^* \), the optimal choice is strategy \( H \); otherwise, strategy \( L \) is optimal. In sum, if the arrival distribution of HVG is uniform, either shipping HVG or shipping LVG is optimal and there is no optimal mixed shipping strategy.

**Exponential distribution (CFR)** The exponential distribution with rate \( \lambda \) is CFR, since \( \lambda(y) = \lambda \). The expected profit of strategy \( H \) is 
\[
\Pi_H = \int_0^\infty \beta^\lambda (\pi_n - cy) \lambda e^{-\lambda y} dy.
\]
To get a closed form result, we first assume there is no discount effect, i.e., \( \beta = 1 \). So we have \( \Pi_H = \pi_a - \frac{c}{\lambda} \), which is decreasing in \( \lambda \), indicating, there exists a critical value \( \lambda_1 = \frac{\Delta}{c} \), such that if \( \lambda > \lambda_1 \), the optimal choice is strategy \( H \); otherwise, strategy \( L \) is optimal. If the waiting cost can be ignored, i.e., \( c \) is relatively small compared with \( \pi_a \), and the discount effect dominates the expected profit, we have 
\[
\Pi_H = \int_0^\infty \beta^\lambda \pi_a \lambda e^{-\lambda y} dy = \frac{\pi_a \lambda}{\lambda - \log \beta},
\]
indicating there exists a critical value \( \lambda_2 = \frac{\pi_a \log \beta}{\Delta} \), if \( \lambda > \lambda_2 \), the optimal choice is strategy \( H \); otherwise, strategy \( L \) is optimal.

Taking both discounting effect and waiting cost into consideration, we have 
\[
\Pi_H = \int_0^\infty \beta^\lambda (\pi_n - cy) \lambda e^{-\lambda y} dy \leq \min \left( \pi_a - \frac{c}{\lambda}, \frac{\pi_a \lambda}{\lambda - \log \beta} \right)
\]
Therefore, there exists a critical value \( \lambda_* \geq \max (\lambda_1, \lambda_2) \), such that if \( \lambda > \lambda_* \), the optimal choice is strategy \( H \); otherwise, strategy \( L \) is optimal. Due to the memoryless property of exponential distribution, the conditional probability of the arrival of HVG does not depend on the past waiting time. A high failure rate \( \lambda \) indicates the probability of the arrival of HVG in the same length of waiting time is high, which indicates the carrier only needs to wait a short time at a small waiting cost, while with high probability the arrival of HVG will come. Thus, waiting for HVG is more profitable.

**Pareto distribution (DFR)** The Pareto distribution is given as
\[
\phi(x) = \left\{ \begin{array}{ll}
\alpha x^\alpha & x \geq 1,
\alpha x^{\alpha - 1} & x \leq 1,
\end{array} \right.
\]
which is DFR, since \( \lambda(y) = \frac{\alpha}{y} \) is decreasing in \( y \in [x_m, \infty) \). The Pareto distribution indicates, the arrival of HVG only occurs after a certain time \( x_m \).

The expected profit of strategy \( H \) is 
\[
\Pi_H = \int_0^\infty \beta^\lambda (\pi_n - cx) \frac{\alpha x^{\alpha}}{x^{\alpha + 1}} dx.
\]
Without discount effect (\( \beta = 1 \)), the expected value is
\[
\Pi_H = \int_0^\infty (\pi_n - cx) \frac{\alpha x^{\alpha}}{x^{\alpha + 1}} dx = \pi_n - \frac{c \alpha x_m}{\alpha - 1} (7)
\]
Therefore, for fixed \( x_m < \frac{\Delta}{c} \), there exists a critical value \( \alpha_* = \frac{\Delta}{\Delta - cx_m} \), such that under \( \beta = 1 \), if \( 1 < \alpha \leq \alpha_* \), \( \Pi_H \leq \Pi_L \); otherwise, \( \Pi_H > \Pi_L \). Incorporating the discount effect, we have a critical value \( \alpha_* \geq \alpha_* \), such that if \( 1 < \alpha \leq \alpha_* \), \( \Pi_H \leq \Pi_L \); otherwise, \( \Pi_H > \Pi_L \). While if \( x_m \geq \frac{\Delta}{c} \), we have \( \forall \alpha > 1 \), \( \Pi_H < \Pi_L \). Therefore, if the time \( x_m \) when the arrival of HVG will not come with certainty is long enough, strategy \( H \) is always dominated by strategy \( L \).

For mixed strategy \( M(y), y \geq x_m \), we have
\[
G(y) = \frac{\Delta}{y} + (\pi_i - cy) \log \beta - c \quad \text{and} \quad G'(y) = \frac{\Delta}{y^2} - c \log \beta.
\]
Therefore, if \( G'(x_m) = -\frac{\Delta}{x_m^2} - c \log \beta \geq 0 \), we have \( \forall y \geq x_m, G(y) \geq 0 \), and the optimal choice is \( \max (\Pi_H, \Pi_L) \); while if \( G'(x_m) = -\frac{\Delta}{x_m^2} - c \log \beta < 0 \), since \( G(y) \) is increasing, \( G(y) \) is eventually positive, and \( G(y) \) is increasing and positive, which indicates \( \Pi_H(y) \) is increasing. We have \( \lim_{x \to \infty} \Pi_H(y) = \Pi_H \). Therefore, the optimal choice is still \( \max (\Pi_H, \Pi_L) \).

From the above examples, we can see under the linear waiting cost, the arrival distribution of HVG is critical in the shipping choice decision. Under IFR and CFR distributions, the carrier either waits for HVG or ships LVG immediately. Only under DFR distributions, there may exist an optimal mixed shipping strategy.

The convex curvature of the waiting cost may also impact the choice decision. However, the existence of the discount effect makes the analysis complicated. To simplify the burden of calculation, we assume \( \beta = 1 \) in the following section, which does not affect the managerial insight. We assume the waiting cost is increasing and convex as \( C(x) = cx^2 \) (the convex curvature can be used to incorporate the discount effect). The expected profit of
strategy $H_2$ is
\[ \Pi_H = \int f(x) \, dx = \pi_n - cE(X) = \pi_n - c(\mu^2 + \sigma^2) \]
. Therefore, the expected profit of strategy $H$ depends on the mean and the variance of the arrival distribution of HVG.

If we know the mean and variance of the arrival distribution, the comparison between the two pure strategies is easily to be determined. For example, for exponential distribution with rate $\lambda$, the expected profit of shipping HVG is
\[ \Pi_H = \pi_n - \frac{2c}{\lambda} \]
. Thus, if $\lambda > \lambda_0 = \frac{2c}{\lambda}$, strategy $H$ has a larger expected profit; otherwise, the expected profit of strategy $L$ is larger.

For mixed strategy $M(y)$, we have the expected profit and the first order derivative with respect to the waiting time $y$ as
\[ \Pi_M(y) = \int f(x) \, dx + \int (\Pi_l - cy^2) \, dx \]

\[ \Pi_M(y) = (1 - F(y))(\Delta \lambda(y) - 2cy) \]

Based on the above assumptions, i.e., $C(x) = cx^2$ and $\beta = 1$, we can get the following result:

**Proposition 2.** For CFR and DFR distributions, the optimal waiting time $y^\hat{}$ (if exists) satisfies $\Delta \lambda(y^\hat{} - 2cy = 0$. For IFR distributions, there may not exist an optimal waiting time $y^\hat{}$.

**Proof:** It is obvious for CFR and DFR distributions, since $\Delta \lambda(y) - 2cy < 0$ and there exists only one $y^\hat{}$ (if exists), such that $\Delta \lambda(y^\hat{}) = 2cy$. For IFR distributions, $\Delta \lambda(y) \geq 0$. Thus, there may exist several or none solutions that $\Delta \lambda(y) - 2cy = 0$. For convex $\lambda(y)$, $\Delta \lambda(y) - 2cy$ is also convex. Therefore, if $(\Delta \lambda(y) - 2cy < 0, (\Delta \lambda(y) - 2cy) > 0$, the optimal choice is $\max(\Pi_H, \Pi_L)$; while if $(\Delta \lambda(y) - 2cy > 0, (\Delta \lambda(y) - 2cy) < 0$, there exists an optimal waiting time $y^\ast$; otherwise, the optimal choice is $\max(\Pi_H, \Pi_L)$. For concave failure rate $\lambda(y)$, $\Delta \lambda(y) - 2cy$ is also concave. Therefore, if $(\Delta \lambda(y) - 2cy < 0, (\Delta \lambda(y) - 2cy) > 0$, the optimal choice is $\max(\Pi_H, \Pi_L)$; while if $(\Delta \lambda(y) - 2cy > 0, (\Delta \lambda(y) - 2cy) < 0$, there exists an optimal waiting time $y^\ast$; otherwise, the optimal choice is $\max(\Pi_H, \Pi_L)$. Therefore, one of the sufficient conditions for the existence of an optimal waiting time $y^\ast$ is $\Delta \lambda(y) - 2cy > 0, (\Delta \lambda(y) - 2cy) < 0$.

For uniform distribution, the failure rate $\hat{\lambda}(y) = \frac{1}{T - y}$ is convex. Therefore, if $\frac{2\lambda}{T} \geq c$, we have
\[ \forall y \in [0, T], \Delta \lambda(y) - 2cy = \frac{\lambda}{T - y} - 2cy \geq 0 \]
indicating the optimal choice is strategy $H$. If $\frac{2\lambda}{T} < c$, there exist two points $y_1, y_2$ satisfying $\Delta \lambda(y) - 2cy = 0$, indicating the optimal choice is $\max(\Pi_H(y_1), \Pi_H(y_2))$. For exponential distribution with failure rate $\lambda$, there always exists an optimal waiting time $y^\ast = \frac{\Delta \lambda}{2c}$. For Pareto distribution, the optimal waiting time is $y^\ast = \sqrt{\frac{\Delta \lambda}{2c}}$ if $y^\ast \geq x_m$; otherwise, the optimal choice is $\Pi_Y$.

Compared with the linear waiting cost, we can see the convex waiting cost changes the optimal shipping choice decision to some extent. For example, under CFR distributions, such as the exponential distribution with rate $\lambda$ in $[0, \infty)$ without discount, for linear waiting cost, the existence of an optimal mixed strategy depends on the comparison between $\Delta \lambda$ and $c$, either $\Pi_H$ or $\Pi_L$ is optimal; while for convex waiting cost, there exists an optimal waiting time $y^\hat{}$ and the mixed strategy $\Pi_H(y^\hat{})$ is optimal. The fundamental reason here is due to the fact that, for small time, the convex waiting cost is larger than the linear waiting cost; while for large time, the convex waiting cost increases faster and is larger than linear waiting cost. Therefore, under convex waiting cost, waiting for some time becomes attracting even it is not optimal under linear waiting cost.

In sum, from the above result, we can see if the arrival distribution of HVG is known, the shipping choice faced by the carrier can be easily determined statically. Whenever the carrier is available at the port of shipment, based on the waiting cost, discount factor and the profit difference, the carrier can decide to ship HVG only (even incurs waiting cost), ship LVG immediately without any waiting cost, or adopt a mixed policy, i.e., waiting for a threshold time and ship HVG if it comes, otherwise ship LVG immediately at the threshold time.

**The case with unknown arrival distribution**

The result in the above section indicates with known arrival distribution of HVG, the shipping choice can be easily made. The known distribution of $X$ is an ideal situation, since in practice, the business opportunity of HVG depends on various factors, and even there exists an experimental distribution about the arrival information of HVG, the actual arrival of HVG may not be easily estimated or forecasted, i.e., the exact information about the arrival information of HVG is not easy to extract. Therefore, the carrier suffers from the lack of information about the arrival of HVG if making the shipping choice decision statically. A dynamic decision making process is needed for the carrier to make wise shipping choice in a one-period model.

In this section, we are interested in the situation when the arrival distribution of HVG is unknown, what will be the optimal shipping strategy? Since the arrival distribution of HVG is unknown, the expected value of shipping HVG cannot be evaluated. Thus, the carrier only needs to compare the expected profit of shipping LVG and the mixed strategy. There are $N$ stages (or days) for the carrier to make the shipping choice. At the beginning of each stage $n = 1, \ldots, N$, the carrier will ship HVG if the business opportunity comes; otherwise, he needs to decide whether
shipping LVG immediately or waiting for HVG in the next stage. For simplicity, we assume the waiting cost is linear and there is no discount effect. Clearly, we need \( \pi_n - cn \geq 0 \) and \( \pi_n - c(N+1) < 0 \), i.e., \( N = \left\lfloor \frac{\pi_n}{c} \right\rfloor \), where \([\cdot]\) takes the integer part from below. Therefore, beyond stage \( N \), there is no profit to ship any goods. Therefore, the dynamic shipping choice making is a typical optimal stopping problem, i.e., what should be the optimal stopping strategy for the carrier to ship LVG after a certain stage when the arrival of HVG has not come yet.

In practice, the business opportunity of shipping HVG depends on the supply and the demand. The higher downstream demand, the more upstream supply, and the more shipping demand thus more business opportunity for the carrier. Therefore, more supply and demand about HVG implies higher probability that the business opportunity of HVG will arrive. There may be other information or events related to the arrival of HVG. In this section, we define the information used in the model as all the events related to the arrival of HVG, and we assume the more information in the current stage, the higher probability of the arrival of HVG occurs in the next stage. Thus, the carrier can use the information to decide whether to continue waiting for HVG or shipping LVG immediately. However, the carrier faces the tradeoff between increased waiting cost and the potential profit gain of shipping HVG. This optimal stopping decision is modeled using a dynamic programming formulation. The state variable is the information about the arrival of HVG, denoted as \( I \). We define \( V_n(I_n) \) as the expected profit of shipping HVG only from period \( n \) to period \( N \), when the current information state is \( I_n \) and HVG is not available. The dynamic programming formulation is given as

\[
V_n(I_n) = E[V_n+1(I_{n+1}),V_{N+1}(I_{N+1})] = 0 \quad (10)
\]

where \( V_n(I_{n+1}) = p(I_n)(\pi_n - cn) + (1 - p(I_n)V_n+1(I_{n+1}) \)

and \( p(I_n) \) is the probability that shipping opportunity of HVG arrives at stage \( n+1 \), which is increasing in \( I_n \). The boundary value \( V_{N+1}(I_{N+1}) = 0 \) indicates at stage \( N+1 \), if HVG is not still available, the carrier will not carry any goods. The state transition function is \( I_{n+1} = I_n + \varepsilon_{n+1} \), where \( \varepsilon_{n+1} \) is the information gathered between stage \( n \) and \( n+1 \), which is random. Therefore, the dynamic programming model is simplified as

\[
V_n(I_n) = p(I_n)(\pi_n - cn) + (1 - p(I_n))V_n+1(I_{n+1} + \varepsilon) \quad (11)
\]

A closed form solution of the value function is not meaningful here. Therefore we investigate the structure property of the stopping decision. Intuitively, the more information, the higher probability of the arrival of HVG in the next stage, and waiting for the arrival of HVG is more attractive. However, since the waiting cost is increasing, the attractiveness of waiting for HVG may be offset. Indeed, we have the following result in terms of the relationship between the waiting decision and the information state in each stage:

**Proposition 3.** There exist decreasing information states \( I^*_1 \geq I^*_2 \geq \cdots \geq I^*_N \) when the stage is in \( 1, \cdots, N \), such that at each stage, shipping HVG if it appears; otherwise, waiting for the next period, if \( I_n \geq I^*_n \).

**Proof:** We prove the value function \( V_n(I_n) \) is increasing (in the weak sense) in \( I_n \) using induction. At each stage \( n \), we have \( \pi_n - cn > 0 \), and \( V_n(I_n) = E[V_{n+1}(I_{n+1})] = p(I_n)(\pi_n - cn) \) which is increasing in \( I_n \). Assume \( V_n(I_n) \) is increasing in \( I_n \). Thus, \( V_n(I_n) \) is increasing in \( I_n \), since the first order derivative in \( I_n \) is

\[
p(I_n)(\pi_n - cn - \int \{\pi_{n+1}(I_{n+1} + \varepsilon)de\} + (1 - p(I_n))V_n+1(I_{n+1} + \varepsilon)) \geq 0,
\]

due to the fact that shipping HVG at the current stage is always better than carrying it in the future, i.e., \( \pi_n - cn - \int \{\pi_{n+1}(I_{n+1} + \varepsilon)de\} \geq 0 \) and \( V_n+1(I_{n+1} + \varepsilon) \) based on the inductive assumption. Thus, \( V_{n+1}(I_{n+1}) \) is also increasing in \( I_{n+1} \).

Clearly, \( V_n(I_n) \) is decreasing in \( n \), i.e., for the same information, waiting more time is not beneficial, since the waiting cost is increasing in \( n \). It is clear that \( V_n(I_n) \) is decreasing in \( n \), since with the same information, \( V_n(I_n) \) can save \( cp(I) \) if HVG is available in period \( n+1 \).

At stage \( n \), the profit from shipping LVG is \( \pi_n - (c(n+1)) \). Thus, it is optimal to wait for HVG, if \( V_n(I_n) \geq \pi_n - (c(n+1)) \). Define the critical information state as \( I^n = \text{arg}\{ I | V_n(I_n) = \pi_n - (c(n+1)) \} \), which indicates, if \( I_n \geq I^n \), waiting for HVG in the next stage, since \( V_n(I_n) \geq \pi_n - (c(n+1)) \) due to the increasing property of \( V_n(I_n) \); otherwise shipping LVG is optimal. We also have \( V_{n+1}(I_{n+1}) = \pi_n - cn = V_n(I_{n+1} - \pi_n) - (1 - p(I_n))V_n+1(I_{n+1} + \varepsilon) \geq 0 \), while the critical information state at stage \( n+1 \) satisfies \( V_{n+1}(I_{n+1}) = \pi_n + cn = 0 \). Therefore, we have \( I^n \geq I^*_n \) since \( V_n(I_n) \) is increasing in \( I \). Thus, the optimal stopping strategy has the following form: there are decreasing information states \( I^n \geq I^*_n \geq \cdots \geq I^*_1 \), such that at stage \( n \), carrying HVG if it arrives, otherwise, waiting for the next stage if \( I_n \geq I^*_n \).

The conclusion can be generalized to increasing and convex waiting cost. The above result indicates at stage \( n \), the carrier should wait additional time if the arrival of HVG is not available in current stage and the information state is beyond a critical point, i.e., the probability that HVG will arrive in the next stage is larger than a critical point. Interestingly, the critical information state which defines the attractiveness of waiting is decreasing when the stage increases. The result seems counter-intuitive, since after waiting some stages, the carrier should be more impatient. Therefore in order for him to wait longer, there should be more information and a higher probability of business opportunities of shipping HVG in the next stage. The result can be understood from a sunk-cost perspective. After the carrier has waited some stages, he has already born some
waiting cost, which is the sunk cost to him. Therefore, the attractiveness of shipping LVG immediately decreases, since the carrier is reluctant to give up the waiting cost, and the attractiveness of waiting for HVG increases, which is reflected from the decreasing critical information state.

The above structural property of the stopping decision in the shipping choice problem can be used to guide the decisions on waiting in practice when the arrival distribution of HVG is unknown. On the one hand, at early stages, waiting for HVG is worthy unless the carrier can be sure that the opportunity of HVG will come in the next stage with high probability; otherwise, he should ship LVG immediately in order to save the sunk waiting cost. On the other hand, if the carrier has waited several stages, he should be more patient to wait longer for the arrival of HVG.

V. DEMAND UNCERTAINTY AND SHIPPING CHOICE

In this section, we focus on the impact of demand uncertainty of LVG on the shipping choice. At stage \( n \), the carrier actually serves as a newsvendor and he needs to decide the optimal order quantity facing the uncertain demand. The carrier may have inaccurate demand information, such as the mean and the variance of the demand distribution. Since the more accurate of the information, the more expected profit of shipping LVG, the carrier may strategically wait some time to collect and update the demand information of LVG. We try to investigate with the ability of demand information updating of LVG, what will be the optimal shipping choice.

We assume the arrival distribution of HVG is static and fixed as exponential distribution with rate \( \lambda \). (Thus, the arrival process is Poisson Process with rate \( \lambda \)). Due to the memoryless property of exponential distribution, the conditional probability of the business opportunity of HVG arriving in the time interval \([t, t+\Delta t]\) is the same as in \([0, \Delta t]\). For simplicity, we assume the waiting cost is linear and no discount effect. There are \( N \) stages from 1 to \( N \) for the carrier to make the shipping decision. The expected profit of waiting for HVG at the beginning of stage \( n \) is

\[
\Pi_n(n) = \pi_n - c \cdot \frac{c}{\lambda} - c(n-1) .
\]

During the waiting, the carrier can forecast and update the demand information of LVG and update the expected profit of shipping LVG by ordering an optimal quantity. The tradeoff is between the increased waiting cost versus the benefit from increased demand information. We assume there is no capacity constraint and the demand information updating is modeled using MMFE (martingale model of forecast evolution) developed by [2,3]. There are several papers focusing on the impact of forecast updating on the inventory problem, especially in the newsvendor context, including two-period model [4,5] and multi-stage inventory systems [6]. For the recent literature review about this topic, see [7], which considers the optimal order strategy in a multi-stage newsvendor model, where the newsvendor can dynamically make orders from a portfolio of suppliers with different lead times and procurement costs. A state-dependent base-stock policy is derived to be optimal based on MMFE in the paper.

There are two alternative models in MMFE: additive or multiplicative depending on the assumption of the forecast update distribution. We use the additive version of MMFE here. The forecast update from stage \( n-1 \) to \( n \) is \( \epsilon_n \), which is distributed as \( N(0, \sigma_n^2) \). The demand at stage \( n \) is \( I_n = \sum_{i=2}^{n} \epsilon_i, I_{n+1} = I_n + \epsilon_{n+1} \). The demand distribution at stage \( n \) is \( D(I_n) : N(\mu_n + I_n, \sigma_n^2) \). Denote \( \sigma_n^2 = \sum_{i=n}^{N} \sigma_i^2 \) in the following section.

We first focus on the value of shipping LVG with forecasting evolution. Since the carrier can only make the shipping choice once, it can be statically made at the beginning of the horizon or it can be made dynamically depending on the carrier's updated demand forecast of LVG. Therefore, we consider two different decision making styles, namely the static model and the dynamic model. We show that under MMFE, the two decision styles are equivalent.

A static model

Here, in the static model, the carrier makes the shipping choice at the beginning of the horizon whether to ship LVG at a certain stage \( n \) with a fixed order quantity or continue waiting for HVG. In stage \( n \), after observing \( I_n \), for the lost sale newsvendor problem with salvage value \( s \), the carrier decides the order quantity to maximize the expected profit as

\[
\pi_n(x) = E(p \min(D(x) - wx + s(x-D))^+ - c_n) .
\]

where the demand is distributed as \( D(I_n) : N(\mu_n + I_n, \sigma_n^2) \) and \( c_n = c(n-1) \) is simplified for the waiting cost at the beginning of stage \( n \). Therefore, the optimal order quantity is given as the following critical point:

\[
F_n(x^*) = \frac{x^* - w}{p - s} = \beta ,
\]

\[
x^*(I_n) = F_n^{-1}(\beta) = \mu_n + I_n + z_{\beta} \sigma_n .
\]

where \( F_n \) is the distribution of \( D(I_n) \), \( z_{\beta} \) is the inverse of standard normal distribution, \( z_{\beta} = \Phi^{-1}(\beta) \). Therefore, the optimal expected profit at stage \( n \) is

\[
\pi_n(I_n) = (p - w)(\mu_n + I_n) - (p - s)\sigma_n \Phi(z_{\beta}) - C_n .
\]

where \( \Phi(x) \) is the probability density of standard normal distribution.

Therefore, at the beginning of the horizon, the expected profit when the carrier decides to order at stage \( n \) and leaves is

\[
\pi_n = E(\pi_n(I_n)) = (p - w)\mu_n - (p - s)\sigma_n \Phi(z_{\beta}) - C_n .
\]

from which, we can see clearly the tradeoff between increased waiting cost \( C_n \) and the benefit from the precision of the demand information, \( \sigma_n \), which is decreasing in \( n \).

At stage \( N+1 \), if the carrier has not made the shipping choice, the business opportunity of shipping is assumed to be lost, i.e., we assume \( \forall I_{n+1}, \pi_{n+1} = 0 \). Therefore, the optimal profit of shipping LVG in the static policy is

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\[ \Pi' = \max_{n=1, \ldots, N+1} \pi_n^a \]  

If we assume the updated forecast information is independent and identical distributed, i.e., \( \sigma_n = \sigma \), we have \( \sigma_n^2 = \sum_{n=1}^{N+1} \sigma_n^2 = (N+1-n)\sigma^2 \). Thus, the expected profit of at the beginning of stage \( n \) viewed at the beginning of the horizon is

\[ \pi_n^a = E(\pi_n^a(I_n)) = (p-w)\mu - (p-s)\phi(z_p)\sqrt{N+1-n-c(n-1)} \]

Taking derivative with respect to \( n \), we get the optimal waiting time which balances the tradeoff between increased waiting cost and the benefit from increased demand information accuracy is

\[ n^* = \lfloor N+1 - \frac{(p-s)\phi(z_p)\sigma^2}{c} \rfloor \]

where \( \lfloor \cdot \rfloor \) represents the integer part of the number from below. If \( n^* > 1 \), the carrier can increase the expected profit from shipping LVG with the ability of forecast updating during the waiting time. The optimal profit of shipping LVG is \( \Pi'(n^*) \).

At \( n^* \), if the business opportunity has not come yet, the expected profit of waiting for HVG is

\[ \Pi_H(n^*) = \pi_n - \frac{c}{\lambda} - c(n^*-1) \cdot \lambda. \]

Therefore, in the static model, at the beginning of the horizon, the carrier can make the shipping choice based on the comparison between \( \Pi'(n^*) \) and \( \Pi_H(n^*) \). If \( \Pi'(n^*) \geq \Pi_H(n^*) \), shipping LVG at \( n^* \) is optimal; if \( \Pi'(n^*) < \Pi_H(n^*) \), shipping HVG if it appears before or on \( n^* \), such that \( \Pi'(n) \geq \Pi_H(n) \); otherwise shipping LVG immediately at \( n \).

A dynamic model

In this case, the shipping choice is determined in a dynamic fashion and contingent on the observed demand information \( I_n \) of LVG. This is also an optimal stopping problem. We first focus on the value of the dynamic strategy of shipping LVG. In any stage \( n \) (if the arrival of HVG has not come yet), after observing \( I_n \), the carrier faces two options: to wait or to order LVG and leave. If he chooses to wait, nothing happens in \( n \) and he moves on to the next stage. The payoff will be the expected return in the next stage, conditional on \( I_n \). If he chooses to order and ship LVG, then the payoff is the optimal expected profit at stage \( n \) with forecast updating. The dynamic programming formulation is given as

\[ V_n(I_n) = \max \left\{ \pi_n^a(I_n), EV_{n+1}(I_{n+1} | I_n) \right\} \]

with the boundary condition \( V_{N+1}(I_{N+1}) = 0 \), where \( V_n(I_n) \) stands for the boundary condition. The optimal profit of the dynamic policy is \( \Pi' = V(0) \) since at the beginning of the horizon, there is no additional demand information about LVG.

Actually, the profit of shipping LVG in the above dynamic fashion is identical to the profit in the static fashion, as shown in the following result:

**Proposition 4. The profits from shipping LVG under MMFE in the static policy and the dynamic policy are the same.**

**Proof:** At stage \( N+1 \), it is clear that \( V_{N+1}(I_{N+1}) = \pi_n^a(I_{N+1}) = 0 \). Assume at stage \( n \),

\[ V_n(I_n) = \max_{n=1, \ldots, N+1} \pi_n^a(I_n) \]

\[ = \max \left\{ \pi_n^a(I_n), EV_{n+1}(I_{n+1} | I_n) \right\} \]

\[ = \max \left\{ \pi_n^a(I_n), EV_{n+1}(I_{n+1}(I_{n+1}(I_{n+1})) \right\} \]

\[ = \max \{ \pi_n^a(I_n), \max_{n=1, \ldots, N} \pi_n^a(I_n) \} \]

where the third equality follows from \( \forall t \geq n, E[\pi_n^a(I_n) | I_{n-1}] = \pi_n^a(I_n) \), since \( I_n = I_{n+1} + \varepsilon : N(I_{n+1}, \tilde{\sigma}^2) \).

Therefore, the expected profit from the dynamic policy is

\[ \Pi' = V(0) = \max_{n=1, \ldots, N} \pi_n^a(0) = \max_{n=1, \ldots, N} \pi_n^a = \Pi. \]

The above result indicates, in terms of shipping LVG, under MMFE, there is no benefit from a dynamic policy compared with the static policy. The similar result is also found in [7] where the newsvendor has only one order chance under MMFE. This seems counter-intuitive, since contingent on the real-time demand information, the carrier would get more benefit from shipping LVG. The reason is due to the characteristics of the MMFE model, the forecast updates are independent and the expected value of the future is equal to the current state. Besides, the increased benefit due to the increased information and the increased waiting cost are fixed and deterministic in each stage. Therefore, under MMFE, the expected profit from shipping LVG dynamically or statically is identically. Thus, the shipping strategy is the same as in the static policy.

A general model

We incorporate the demand uncertainty of LVG and the arrival uncertainty of HVG in a synthesized model. We define the state as \((I_n, I_{n+1})\) and the dynamic model is simply formulated as

\[ \Pi'(I_n, I_{n+1}) = \max \left\{ \pi_n^a(I_n), V_{n+1}(I_{n+1}) \right\} \]

and \( \pi_n^a(I_n) = (p-w)(\mu + I_n^T) - (p-s)\phi(z_p) - C_s \) and \( V_{n+1}(I_{n+1}) = p(I_{n+1} + \xi) \phi(z_{n+1}) \left( 1 - (1 - p(I_{n+1} + \xi)) \right) \).

Therefore, at stage \( n \), the critical information state satisfies \( V_n(I_n) = \pi_n^a(I_n) \), indicating for every given \( I_n \), there exists a corresponding \( I_{n+1} \), such that if \( I_n > I_{n+1} \), waiting for the next stage (since HVG has not come yet), otherwise shipping LVG; for given \( I_n \), there exists a corresponding \( I_{n+1} \), such that if \( I_n > I_{n+1} \), waiting for the next stage, otherwise shipping LVG. For instance, waiting for the next stage (since HVG has not come yet), otherwise shipping LVG; for given \( I_n \), there exists a corresponding \( I_{n+1} \), such that if \( I_n > I_{n+1} \), waiting for the next stage, otherwise shipping LVG.
one $I^{-i}_n$, since the value of each choice is increasing in the corresponding information state. Compared with previous section, we can see the decreasing property of $I^{H*}_n$ does not hold due to the existence of random information state $I^L_n$. We investigate without the impact of $I^L_n$, whether we have the same structure property. Therefore, we use the expected value $\pi^*_n$ to substitute for $\pi^*_n(I^L_n)$, i.e., assuming $I^L_n = 0$, and we have the critical information state in stage $n$ as $I^{H*}_n = \arg_{\mu} \{ I | V_n(I^{H*}) - \pi^*_n(n) + c(n-1) = 0 \}$, where we assume $\sigma^2 = \sigma^2$, and $\pi^*_n(n) = (p-s)\phi(z_\beta)\sigma\sqrt{N+1-n}$ which is increasing in $n$.

Correspondingly, the critical information state in stage $n+1$ is $I^{H*}_{n+1} = \arg_{\mu} \{ I | V_{n+1}(I^{H*}) - \pi^*_n(n+1) + cn = 0 \}$. We also have

$$V_{n+1}(I^{H*}) - \pi^*_n(n+1) + cn = V_n(I^{H*}) - p(I^{H*})c - \pi^*_n(n+1) + cn,
= (I - p(I^{H*}))\mu - \frac{(p-s)\phi(z_\beta)\sigma}{\sqrt{N+1-n} + \sqrt{N-n}}$$

where the first part is the expected increased waiting cost in stage $n+1$, and the second part is the increased expected profit from LVG due to more accurate demand information. Thus, we can clearly see the tradeoff between increased information and increased waiting cost.

Suppose $I^{H*}_n$ is increasing in $n$. $\{1 - p(I^{H*}_n)\}$ is increasing in $n$ and the second part is also increasing in $n$. The difference of these two forces may be negative. Under this situation, we will have $I^{H*}_{n+1} \geq I^{H*}_n$, which contradicts the decreasing hypothesis of the critical information state. Therefore, the decreasing property of $I^{H*}_n$ may not be hold. On the other hand, if we assume $I^{H*}_n$ is increasing in $n$, $\{1 - p(I^{H*}_n)\}$ is increasing in $n$, the second part is increasing in $n$. If

$$\{1 - p(I^{H*}_n)\} - \frac{(p-s)\phi(z_\beta)\sigma}{\sqrt{N+1-n} + \sqrt{N-n}} \leq 0,$$
we will have $\forall 1 \leq n \leq N$, $\{1 - p(I^{H*}_n)\} - \frac{(p-s)\phi(z_\beta)\sigma}{\sqrt{N+1-n} + \sqrt{N-n}} \leq 0$, which indicates the increasing property of $I^{H*}_n$ can be hold. In sum, the structure property of $I^{H*}_n$ is not necessarily hold in general.

The above result indicates, with the ability of forecast updating of the demand information about LVG, under the unknown information about the arrival of HVG, the shipping choice may depend on several factors, and a contingency dependent shipping strategy is needed in practice.

VI. A WAITING STRATEGY WITH BAYESIAN UPDATING

In previous sections, we focus on the one-period model, where the carrier only makes one shipping choice. The carrier can make the shipping choice by a static fashion or a dynamic fashion with or without perfect information about the arrival distribution of HVG. The arrival distribution of HVG is either assumed to be completely known or unknown. Generally, the arrival distribution of HVG can not be fully acquired. In practice, the carrier always adopts a mixed shipping policy in order to transport HVG, since the profit from HVG is relatively large while the risk is relatively small and during the waiting, the demand information about LVG can be updated. The carrier will use the cargo ship several years and he can get more and more information from the past experience and use these information to further assist the future decision making. Therefore, in this section, we consider a multiple-period situation under the imperfect information about the arrival distribution of HVG where the carrier needs to decide the waiting time for each transport. The carrier has a prior information about the arrival distribution but with uncertain parameters. The carrier can update the arrival distribution based on the past experiences or observations which will depend on his previous waiting decisions.

If the exact arrival time during each shipping can be observed, no matter how long the waiting time is, the carrier can estimate the distribution more accurately with more realizations. This situation is defined as the observed lost opportunity case. While if the exact arrival time can be observed only when the arrival of LVG occurs before or on the the threshold waiting time during each shipping, the waiting-time decision will be critical for the carrier to estimate the arrival distribution. This situation is defined as the unobserved lost opportunity case.

In this section, we investigate the structural property of the waiting-time decisions under different situations. We assume the carrier knows the arrival distribution family with unknown parameters which is characterized by a distribution. The carrier needs to estimate the parameter based on the past arrival realizations. Some statistical models and tools have been developed to estimate the parametric distribution with censored data, such as the Kaplan-Meier (KM) estimator [8]. In inventory management, a few papers have discussed the estimation of demand distribution and the optimal order policies under censored demand data. The papers [9-11] studied dynamic inventory policy when the demand density has unknown parameters and is a member of the exponential and range families. They showed that an adaptive order-up-to policy is optimal where the order-up-to level depends on the life history through a sufficient statistic. Azoury [12] extended the work to more general demand distributions and provides conditions under which finding the optimal policy under Bayesian updating reduces to solving a stochastic dynamic programming problem with a one-dimensional state space. Lariviere and Porteus [13] examine an inventory setting with a specific demand distribution that belongs to a family called news-vendor distributions. Ding et al. [14] study a general demand distribution in a two-period inventory model, and the optimal order quantity is proved no less than the one in the myopic policy under censored demand data. Intuitively, the structural property of the optimal order quantity in multi-stage problem should be hold as in two-stage model. To generalize the model in Ding et al. [14] to a multi-stage model with censored observation, Lu et al. [15] prove the structural property holds using a sample path analysis.
Bensoussan et al. [16] then provide an alternative method to proof the claim using the concept of the unnormalized probability, which simplifies the dynamic programming equation considerably.

Based on the above literature, in this section, we also use the Bayesian updating mechanism for the carrier to update the arrival distribution under the unobserved lost opportunity case. It turns out that the structural property of the optimal waiting-time decision is identical to the order quantity decisions in the censored newsvendor problem.

**Observed lost opportunity case**

Under the observed lost opportunity case, the carrier can get all the realizations of the arrival of HVG, even if it comes after the ship is loaded with LVG. Assume the arrival time of HVG $X$ belongs to some distribution family, with the density function as $\psi(x \mid \theta)$ and the CDF as $\Psi(x \mid \theta)$, where the parameter $\theta \in \Theta$ is unknown. The carrier has a prior distribution of $\theta$, denoted as $\mu_\theta(\theta)$ at the beginning of each period $n$. Given the prior distribution of $\mu_n(\theta)$ and an observation of the arrival time $x_n$, the posterior distribution of $\theta$, denoted as $\mu_{n+1}(\theta \mid x_n)$ is given by the Bayesian rule

$$
\mu_{n+1}(\theta \mid x_n) = \frac{\psi(x_n \mid \theta)\mu_n(\theta)}{\int \psi(x_n \mid \theta)\mu_n(\theta) \, d\theta}
$$

(23)

which will serve as the prior in period $n+1$.

The estimated arrival distribution at the beginning of period $n$ is given as

$$
\Phi_n(x) = \int \psi(x \mid \theta)\mu_n(\theta \mid x_n) \, d\theta
$$

(24)

For the ease of expression, we assume the domain of the arrival time is nonnegative in the interval $[\underline{x}, \overline{x}]$, where $\overline{x}$ may be $\infty$. Therefore, the expected profit in each period $n$ with prior $\mu_n$ and waiting-time decision $y_n$ is

$$
\Pi(n, \mu_n) = \int_0^{y_n}(\pi_n - C(x))\Phi_n(x) \, dx \\
+ \int_{y_n}^\infty (\pi_n - C(y_n))\Phi_n(x) \, dx
$$

(25)

and the optimal waiting time in each period $n$, defined as $y_n^M$ is assumed to be interior in the domain, i.e., the function $\Pi(y_n, \mu_n)$ is assumed to be unimodal (for example, the exponential distribution with convex waiting cost). The strategy is defined as the myopic shipping strategy, since it only cares about the expected profit in current period.

For the observed lost opportunity case, the dynamic programming formulation is given as

$$
V_n(\mu_n) = \max_{y_n} \{\Pi(n, \mu_n) + \beta E V_{n+1}(\mu_{n+1})\}
$$

(26)

$$
= \max_{y_n} \{\Pi(n, \mu_n) + \beta \int_0^{y_n} V_{n+1}(\mu_{n+1}(\theta \mid x))\Phi_n(x) \, dx \\
+ \beta \int_{y_n}^\infty V_{n+1}(\mu_{n+1}(\theta \mid x))\Phi_n(x) \, dx\}
$$

Since the waiting time in each period is independent of the arrival realization, at period $n$, after observing the arrival time in the previous period $x_{n-1}$, the posterior is updated as $\mu_n(\theta \mid x_{n-1})$, and the estimated arrival distribution is updated as $\Phi_n(x)$. Therefore, in each period, the problem is equivalent to the one period problem, and the optimal waiting time is $y_n^M$ based on the updated arrival distribution.

**Unobserved lost opportunity case**

Under unobserved lost opportunity case, the exact arrival realization can only be observed when the arrival of HVG comes by the waiting time. Therefore, the waiting-time decision impacts the arrival observation. Based on the Bayesian updating rule, the posterior is updated as

$$
\bar{\mu}_{n+1}(\theta \mid x_n) = \int \psi(x_n \mid \theta)\bar{\mu}_n(\theta) \, d\theta
$$

(27)

where $\mu_{n+1}(\theta \mid y_n)$ is given as the following

$$
\bar{\mu}_{n+1}(\theta \mid y_n) = \frac{\int \psi(x_n \mid \theta)\bar{\mu}_n(\theta) \, d\theta}{\int \psi(x_n \mid \theta) \, d\theta}
$$

The estimated arrival distribution is given as

$$
\bar{\Phi}_n(y_n) = \int \psi(x \mid \theta)\bar{\mu}_n(\theta \mid x_n) \, d\theta
$$

Therefore, the expected profit in each stage with prior $\bar{\mu}_n$ and waiting-time decision $y_n$ is

$$
\Pi(y_n, \bar{\mu}_n) = \int_0^{y_n}(\pi_n - C(x))\bar{\Phi}_n(x) \, dx \\
+ \int_{y_n}^\infty (\pi_n - C(y_n))\bar{\Phi}_n(x) \, dx
$$

(30)

The dynamic programming formulation under unobserved lost opportunity case is given as

$$
V_n(\bar{\mu}_n) = \max_{y_n} \{\Pi(y_n, \bar{\mu}_n) + \beta E V_{n+1}(\bar{\mu}_{n+1})\}
$$

$$
= \max_{y_n} \{\Pi(y_n, \bar{\mu}_n) \\
+ \beta \int_0^{y_n} V_{n+1}(\bar{\mu}_{n+1}(\theta \mid x))\bar{\Phi}_n(x) \, dx \\
+ \beta \int_{y_n}^\infty V_{n+1}(\bar{\mu}_{n+1}(\theta \mid x))\bar{\Phi}_n(x) \, dx\}
$$

(31)

The optimal waiting-time decision is defined as $y_n^M$. The above model is difficult to solve, since the transition function depends on previous arrival realizations. From the above formulation, we can find that there exists a critical tradeoff between the current profit and the future benefit due to the waiting-time decision. For a given prior, waiting too long will decrease the expected profit in the current period. However, a more concise information about the arrival distribution will be derived, since waiting a little longer can increase the chance of observing additional arrival realization, which will benefit the future decisions.

We investigate the structural property of the optimal waiting-time decision path. We first define the myopic policy as the decisions in each period which maximize the expected profit under the current distribution information as

$$
y_n^M = \arg\max_{y_n} \Pi(y_n, \bar{\mu}_n) .
$$

We have the following structural property of the optimal waiting-time path:

**Proposition 5.** Compared with the myopic waiting time, under the unobserved lost opportunity case, the optimal waiting time in each period is no less than the myopic
waiting time, i.e., \( y^d_n \geq y^M_n \).

Proof: The proof can be used a sample path analysis as similar as that in Lu et al. [15] or the unnormalized probability introduced in Bensoussan et al. [16]. Both of the papers provide an alternative proof of the structural property in the optimal order quantity in the multiple-period newsupplier problem with censored observation. Our problem of optimal waiting time under unobserved lost opportunity case is equivalent to the optimal order quantity in the newsvendor model with censored observation. Therefore, the proof is omitted here.

The above result indicates under the unobserved lost opportunity case, the optimal waiting time should balance the tradeoff between short-term profit and long-term benefit. It is clear that as the period \( n \) increases, the difference between the optimal waiting time and the myopic one will become smaller and smaller, since there will be enough observations of the arrival realizations and the estimated arrival distribution will become more accurate even under myopic policy.

VII. SUMMARY, MANAGERIAL INSIGHT AND FUTURE RESEARCH

Summary

A decision making process always involves a choice among multiple alternatives. To make a wise choice, decision makers need to analyze the tradeoffs in each choice. One critical tradeoff in management decision making is between the short-term interest and long-term benefit. Based on the practical situation in cargo ship transport, in this paper, we focus on the shipping choice problem faced by the carrier. The carrier can choose to either ship HVG with fixed freight given uncertain supply of goods, or ship LVG with less profit given uncertain demand of goods. The objective of the carrier is to make a wise shipping choice in order to maximize the potential profit.

Under various situations, a wise shipping choice needs to balance the tradeoff between expected profit margin and potential waiting cost. For a one-period model, we first concentrate on the shipping choice due to the supply uncertainty of HVG. Under the situation with a known arrival distribution of HVG, we demonstrate that the failure rate of the arrival distribution plays an important role. For IFR and CFR distributions, there is no optimal mixed strategies, and the carrier either waiting for HVG or shipping LVG immediately. However, for DFR distributions, there may exist an optimal mixed strategy with higher expected profit than pure strategies. Under the situation with unknown arrival distribution of HVG, the shipping choice problem is converted to an optimal stopping problem, i.e., whether continuing to wait for the arrival of HVG (if it does not come yet) or stopping and shipping LVG immediately. A dynamic model is developed to show that a threshold policy should be adopted in terms of the arrival probability of HVG, in the sense that the carrier should stop waiting if the arrival probability is below a critical value in each stage. Due to increased waiting cost, the critical value is decreasing in waiting time.

The demand uncertainty of LVG can also impact the shipping choice. The carrier can strategically wait to update the demand information about LVG and the arrival information about HVG before selecting the shipping choice. The carrier updates the demand information based on the MMFE model. Under exponential arrival distribution of HVG, the shipping choice made statically is equivalent to that in a dynamic model. With demand forecast updating, the carrier can benefit from the strategic waiting decision. If the arrival distribution of HVG is unknown, a contingency based shipping strategy may be optimal during the increased expected profit of shipping LVG.

If the carrier has multiple shipping choices to make, under the situation with imperfect arrival distribution, he can update the arrival distribution based on the previous experiences. We therefore concentrate on the optimal waiting-time decisions in a multiple-period model based on the Bayesian updating mechanism. Under observed lost opportunity case, the carrier is simply adopt the optimal waiting time in single period model based on the updated arrival distribution, i.e., the myopic waiting strategy. Under unobserved lost opportunity case, the carrier can observe the arrival realization only when the arrival realization occurs on or before the waiting time. It turns out that the optimal waiting time in this case is no less than one in the myopic policy.

Managerial insight

From the shipping choice decision making in bulk transport, we can see the tradeoffs in each choice under different situations. Under known arrival distribution of HVG and demand distribution of LVG, the tradeoff is between the profit margin and the potential waiting cost when the carrier decides to ship HVG. The carrier may adopt a mixed strategy to balance the tradeoff. However, the result indicates, there may not exist an optimal mixed strategy under some conditions. Under unknown arrival distribution of HVG, the carrier can make the shipping decision dynamically. The tradeoff associated with the waiting decision is the increased waiting cost and the updated information about the arrival of HVG. Therefore, the carrier should make the shipping decision to balance these two forces. With the ability of forecast updating about the demand of LVG, the carrier can achieve the benefit from accurate information. However, the waiting decision should balance the tradeoff between the increased waiting cost and the improved demand information. If the carrier ships multiple times, under the unknown arrival distribution parameter, the arrival distribution can be updated based on previous experience. However, if the lost shipping opportunity of HVG is unobservable, the carrier needs to decide the waiting time to balance the tradeoff between short-term profit and the long-term benefit. In sum, the shipping choice and associated waiting-time decision should be determined to make a balance between the inherent critical tradeoffs between short-term interest and long-term profit.

Future research

It would be interesting to investigate the interplay between manager's risk attitude and the long-term vs. short-term tradeoffs. Time preference attitude, namely the extent of patience, of the decision maker is another important factor in such decision-making context. Empirical evidences of the above-mentioned factors in other
managerial decision-making contexts such as investment, human capital development, and productivity can be further researched.

REFERENCES

ABSTRACT

When Taiwan joins World Trade Organization and National Health Insurance (NHI) program has been implemented, dental services marketing has become crucial and competitive in Taiwan. This study uses RFM (recency, frequency, and monetary) model along with self-organizing maps to segment dental patients of a children’s dental clinic in Taiwan. Four clusters are recommended for the overall 1,532 patients. The average values of R and F variables are computed for each cluster and the overall patients, excluding monetary which is covered by NHI program. The results show that one cluster with both R and F values (506 patients) greater than the overall average R and F values can be viewed as loyal patients, and the dental clinic needs to pay much attention to this group. One group with 238 patients have larger recency value but the other two clusters with 788 patients have smaller average R and F values.

Keywords: dental marketing, RFM model, self-organizing maps, market segmentation, loyal customer.

INTRODUCTION

Capon [6], Wang et al. [48], and Rutsohn and Ibrahim [43] have addressed that marketing strategies have been an essential issue for medical care industry particularly in dental care. There is no exception to Taiwan’s medical care industry because this industry has rapid growth when Taiwan joins World Trade Organization. In addition, with the introduction of the new total payment rule of National Health Insurance (NHI) program executed by Bureau of National Health Insurance of the government in Taiwan since March 1995, Lee et al. [33] and Shieh et al. [44] summarized that the medical care industry has become very competitive, including dental services. Lee and Shih [34] pointed out that this cost-containment mechanism and global budgeting systems for dental care covered as part of the benefit package in NHI program in Taiwan are unique. A dentist’s income is limited when serving a dental cares covered by NHI program as NHI program will cover most of cost except for the co-payment and registration fee per visit. Under such system and competitive environment, it is critically important for dent clinics to actively identify profitable customers and to retain important customers so as to market dental services.

RFM (Recency, Frequency, and Monetary) model has been widely applied for market segmentation to identify valuable customers [8] [11] [50] [52]. Before the use of RFM model, the number of clusters must be determined. In this study, self-organizing maps (SOM) will be used to segment customers since SOM can help the market managers easily recognize the market segments precisely and compare market maps over time and monitor market responses of every segment [19]. In this case study, the focus is on a children’s dental clinic with 1,532 patients who visited this children’s dental clinic from July 16, 2009 to July 15, 2010 for at least once. The profile for each patient includes the membership number, gender, birth date, the last visit date, and visit frequency. Because the dental care is included in NHI program such that monetary value is proposed to be fixed in this study.

This paper is organized as follows. Section 2 briefly reviews self-organizing maps and RFM model. A case study in a children’s dental clinic in Taiwan is presented in Section 3. Finally, conclusions are drawn in Section 4.

LITERATURE REVIEW

Self-organizing Maps

Clustering techniques are one of the data mining techniques and very practical to divide all customers into appropriate number of clusters based on some similarities among these customers [10] [18] [22] [32] [51]. The philosophy is to both minimize within-group variation and maximize between-group variation in accordance with a distance or dissimilarity function to identify a set of groups. Self-organizing maps is one of the very common clustering techniques applying unsupervised neural network method to clustering, visualization and abstraction, and market screening [16] [19] [21] [24] [28] [49]. Zhang et al. [55] pointed out that SOM is a competitive and cooperative neural network that the theory is motivated by observing the operation of the brain [28].

Self-organizing maps is trained by an unsupervised competitive learning algorithm and can automatically detect strong features in large data sets. While self-organizing maps maximizes the degree of similarity of patterns within a cluster and minimize the similarity of patterns belonging to different clusters, SOM can produce two-dimensional arrangement of neurons from the multi-dimensional space [1] [28]. Thus, the complexity of the information from multi-dimensional space can be simplified and understood much easier. In addition, SOM network includes an input layer and an output layer [21]. Originally, the patterns of self-organizing maps in a high-dimensional input space are very complicated. After SOM maps similar input vectors onto similar output units on a two-dimensional map, its structure on a projected graphical
map display becomes more transparent and more understandable. Therefore, self-organizing maps provides the recognizable technique of the inherent relation between the input and output [12] [13] [24] [55]. More importantly, this unsupervised method can be applied to cluster data without prior knowing the class memberships of the input data [19].

For more information about self-organizing maps, please refer to Kohonen [30] [31] and Yin and Allinson [54].

**RFM model**

RFM model is a well-known customer value analysis method widely applied for market segmentation [8] [9] [11] [52]. It is a behavior-based model to analyze the behavior of a customer and then make predictions in accordance with the behavior in the database [23] [53]. RFM models is composed of three measures, namely recency, frequency, and monetary, and the definitions are described below [50]. Recency is defined as the number of periods such as days, months, or years since the last purchase. Frequency measures the number of purchase made in a given time period, while monetary measures the total amount of money spent during a given period of time or the average dollar amount per purchase or all purchases to date.

The general way to use RFM model in customer behavior analysis is to sort the customer data by each dimension of RFM variables and then divide the data into five equal quintiles. For recency, the customer database is sorted by purchase dates by descending order. Thus, the top segment is given a value of 5 and the others are descendingly assigned of 4, 3, 2, and 1. For frequency and monetary, sorting customer visiting frequency data and the customer data related to the amount of the money spent in descending order, respectively. The top 20% is assigned the value of 5. The value of 4 is given to the next 20% and so on [23] [26] [47]. These three variables belong to behavioral variables and can be acted as the segmenting variables by observing customers’ attitudes toward the product, brand, benefit, or even loyalty from the database. Marcus [40] suggested that using average purchase amount instead of total accumulated purchase amount is better in order to reduce co-linearity of frequency and monetary. Finally, all customers are presented by 555, 554, 553, ..., 111, which thus creates 125 (5×5×5) RFM cells. Moreover, the best customer segment is 555, while the worst customer segment is 111. Based on the assigned RFM behavior scores, customers can be classified into segments and their profitability can be further analyzed [4] [5] [9] [42].

Miglautsch [42] pointed out that the above RFM scoring method is called customer quintile method, which is to sort customers in descending order, i.e., from the best to the worst. The advantage is to yield equal number of customers in each segment. This method, however, has a major disadvantage. It encounters several scoring challenges in the measure of frequency and is relatively sensitive, which leads to break apart customers who have identical behavior at the lower quintiles but group customers together whose buying behaviors have significant differences [2].

Behavior quintile scoring method developed by John Wirth is another approach to sort customers based such that each quintile may have different number of customers. For instance, frequency can be divided into five intervals, including 0-3 months, 4-6 months, 7-12 months, 13-24 months and 25+ months, which are coded as 5, 4, 3, 2, and 1, respectively [41]. Miglautsch [42] proposed an approach and the philosophy is below. The score of frequency is defined that the single purchasers are assigned as a score of 1. Then, average the remaining frequency values to determine the mean. Once a customer’s total frequency value is lower than the mean, a score of 2 is given to this customer. The process may be repeated more than two times. For monetary, five quintiles are still created and each has equal amounts of sales [50].

In addition to use the value of each cell to judge whether the customer is valuable, Liu and Shih [37] [38] and Sohrabi and Khanlari [45] suggested that the combinations of RFM can be used by assigning ↓ or ↑ based on the average R (F, M) value of a cluster being less than or greater than the overall average R (F, M) value. Under such circumstances, eight segments can be created. The composite value of RFM is obtained via multiplying normalized RFM values of each customer and the weight of RFM variables.

RFM model measures when people buy, how often they buy, and how much they buy. By using the past purchase data, firms can identify which customers might be worthy to be contacted and predict their future purchase behaviors. Sohrabi and Khanlari [45] and Colombo and Jiang [15] concluded that RFM models are often developed to target marketing programs such as direct mail for particular customers in order to improve response rates, revealing that RFM facilitates to choose which customers to target with an offer. Hughes [23] and Kahan [26] stated that firms can receive much benefit from RFM model including encompassing increased response rates, lowered order cost, and greater profit.

RFM model has been widely applied in many practical areas such as nonprofits, financial organizations, government agencies, on-line industry, travel industry, telecommunication industry, and marketing industry [17] [20] [25] [29] [35] [36] [39] [45] [46]. Moreover, RFM model can be used to segment customers, calculate customer value, compute customer lifetime value, observe customer behavior, estimate the response probability for each offer type, and evaluate on-line reviewers.

Several studies have been successful reported about RFM model in identifying customers and analyz customer profitability. Kaymak [27] used RFM variables as features for characterizing the customers when examining how fuzzy clustering can be used to obtain target selection models. Tsai and Chiu [47] introduced a novel purchased-based market segmentation methodology in accordance with product specific variables such as the purchased items and associated monetary expenses from transactional customer histories to improve unreliable segmentation result due to the traditional adoption of general variables such as customer demographics and lifestyle to segment a market. Jonker et al. [25] provided a
decision support system to determine mailing frequency for active customers. The system observes the mailing pattern of customers in terms of RFM variables and provides mailing policies for multiple time periods. The mailing decision process is modeled through a Markov decision chain. Lumsden et al. [39] applied RFM model to distinguish customer value in accordance with pre-purchase motivations of membership initiation in and all-inclusive travel vacation club. Chan [7] proposed an approach that combines customer targeting and customer segmentation for campaign strategies using RFM to identify customer behavior and a customer lifetime value model to evaluate proposed segmented customers through examining Nissan automobile retailer.

**CASE STUDY**

This case study is based on a children’s dental clinic in Taiwan to identify profitable customers. This dental clinic begins its operation since September 17, 1995. In addition, the patients must be less than 18 years old in order to be classified as children by definition. When the patients become 18 years old, they must go to an adult dental clinic instead. Thus, the “age” factor in this children’s dental clinic should be taken into account. This study collects the data set with 1,532 patients who visited this clinic from July 16, 2009 to July 15, 2010. The profile for each patient consists of the membership number, gender, birth date, the last visit date, and visit frequency. Monetary value for each patient is excluded in the profile as the majority of a dentist’s income is from the co-payment and registration fee per visit by NHI program in Taiwan [34]. Therefore, monetary value is proposed to be fixed. Under such circumstance, only R and F variables are taken into account. The definitions of L and R variables are as follows. Recency is defined as the number of days since the last visit from July 16, 2009 to July 15, 2010. In this study, the assigned value on July 16, 2009 is one, and the value on July 15, 2010 is 365. Therefore, the smallest number of recency is one, while the maximum value is 365. Frequency refers to the number of visit in the same period of time. Thus, the frequency can be measured by counting the number of times a particular patient visits the dental clinic from July 16, 2009 to July 15, 2010.

Among 1,532 patients, 779 patients are male, while 753 patients are female. The majority of patients fall in the ages of 6-10, where the maximum and minimum ages are 17 and 1, respectively. The descriptive statistics for R and F variables of the entire group are presented in Table 1, where max, min, average, and STD represent the maximum value, minimum value, average value of the entire group, and the standard deviation of the entire group, respectively. For the recency, the larger the recency value is, the more recent the patient visits. The maximum and minimum recency values are 365 and 1, respectively. For the frequency, the maximum and minimum values are calculated to be 24 and 1, respectively.

<table>
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<th>Table 1 The descriptions of recency and frequency</th>
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<td><strong>Recency</strong></td>
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</tbody>
</table>

In order to segment patients into appropriate number of clusters, SOM is applied to determine the number of clusters. Based on Figure 1, four clusters are recommended among 1,532 patients when recency and frequency are the two input variables. Table 2 provides descriptive statistics of these four clusters, including the sample size, gender distribution, average age, average recency, and average frequency. Cluster 1 has the largest number of patients with 506, while Cluster 4 has the smallest number of 238. In addition, the patients in Cluster 1 is the youngest patients with the average age of 7.28 among four clusters.

![Figure 1 Four clusters recommended by SOM](image)

**Table 2 Descriptive statistics of four clusters based on SOM technique**

<table>
<thead>
<tr>
<th>Cluster</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Patients</td>
<td>506</td>
<td>472</td>
<td>316</td>
<td>238</td>
<td>1,532</td>
</tr>
<tr>
<td>Male Patients</td>
<td>272</td>
<td>228</td>
<td>156</td>
<td>123</td>
<td>779</td>
</tr>
<tr>
<td>Avg. R</td>
<td>296.4</td>
<td>172.8</td>
<td>230.8</td>
<td>264.2</td>
<td>239.8</td>
</tr>
<tr>
<td>Avg. F</td>
<td>5.91</td>
<td>1.00</td>
<td>2.00</td>
<td>3.00</td>
<td>3.14</td>
</tr>
<tr>
<td>Avg.age</td>
<td>7.28</td>
<td>8.99</td>
<td>8.87</td>
<td>8.65</td>
<td>8.35</td>
</tr>
<tr>
<td>Item(s) above average</td>
<td>RF</td>
<td>---</td>
<td>---</td>
<td>R</td>
<td>---</td>
</tr>
</tbody>
</table>

Based on Table 2, Cluster 1 has the largest R value and F values among four clusters. Cluster 4 has the second largest R value, which is also larger than the average of the entire group, and has the second best F value, which is less than the average. In contrast to Clusters 1 and 4, Cluster 2 has the lowest R and F values among four clusters. When the resources are limited, this dental clinic might put less on these patients since they have not been visited for more than six months. This might indicate that these patients might turn to other dental clinic for services. Cluster 3 has slightly lower than the average R value but the second lowest F value. This shows they have not been to this dental clinic for more than four months. However, compared with Cluster 2, these patients tend to visit the dental clinic more. Therefore, the dental clinic might use some resources to encourage patients to come back.

Cluster 4 has relatively high R value but slightly lower than the average F value. This might indicate that they are new
customers. Pertaining to the marketing strategies for customers in Cluster 4, the dental clinic should enhance customer relationship management to keep in touch with the patients and find ways to meet their demand by attracting them to visit more often. For example, special attention and treatment is particularly vital to children patients when receiving dental care [3].

The patients in Cluster 1 have both largest R and F values, far better than the average values. These patients might be the core customers since they have a relatively closer relationship with the dental clinic by visiting more recent and more frequent. They are loyal both in attitude and behavior in the dental clinic. Loyal customers are profitable as they would contribute positively to the success of their dental care experience. Therefore, the dental clinic should focus on the patients in Cluster 1.

CONCLUSIONS

Marketing expertise plays a vital role of dental clinics in remaining viable in the dental market [34]. Customers believe dental advertising can be done according to each unique taste and dentists should market their services [14]. A successful marketer must identify the needs of customers in different segments [6]. This paper uses RFM model along with self-organizing maps to classify patients and target important patients in a children’s dental clinic in Taiwan. Four clusters are formed by SOM. Patients in Cluster 4 are new customers. The strategy for this dental clinic is to strengthen the interaction with the patients in order to maintain a long-term dental care relationship. Besides, the dental clinic can make more dental advertising or adopt some promotional channels such as offering discount for recommending friends and free registration fee to enhance the number of the visit of patients. The patients in Cluster 1 are the most important patients for the clinic. They would be regarded as the highest loyal customers in the clinic, revealing the necessary for the dental clinic to committing more resources to the patients. To increase the frequency of the patients, the dental clinic can provide better after-medical care activities and small gifts with the provision of the medical services.

Acknowledgement

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ATTRACTIONNESS OF ALTERNATIVES IN INFORMATION SYSTEMS CONTINUANCE:
A CASE OF WIMAX

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ABSTRACT

WiMAX, commercialized for the first time in Korea in 2006. To attract WiMAX users, the WiMAX service provider, KT, offered a six month of free WiMAX services. After the six months, many users did not continue using WiMAX service but switched to other Internet access services. Not only attracting new users but also retaining existing users is crucial for the WiMAX business success. Previous research based on Information Systems (IS) continuance model explains the determinants of IS continuance mainly from the technology user perspective. However, a WiMAX users has double roles, technology user and service consumer. Rational economic assessment is essential for consumer decision makings. Marketing and economics literature explain that value assessment and comparison with alternatives are two main issues in rational economic assessment. This study examines WiMAX service continuance by integrating rational economic perspective and technology user perspective. The testing results based on the data collection from 200 WiMAX users show the significance of attractiveness of alternatives and user satisfaction in determining WiMAX continuance. Customer value further affects WiMAX continuance intention indirectly through user satisfaction. This study provides important implications for research by adding the rational economic assessment to the IS continuance model. This study also provides suggestions for practitioners regarding how to promote WiMAX continuance.

Keywords: WiMAX, IS continuance model, rational economic assessment, attractiveness of alternatives.

INSTRUCTION

WiMAX is the wireless broadband Internet services for mobile devices including laptops, cell phones, and smart phones. It is characterized by its high mobility and accessibility anytime and anywhere. WiMAX enables users to access Internet even when they are moving at speeds up to 120 km/h. After the Korea WiMAX standard was selected as a global standard by the Institute of Electrical Electronics Engineers (IEEE) in September 2005, the WiMAX service provider (KT) launched WiMAX service first in Korea in July 2006. As the number of users of smart phones and tablet PCs increases, WiMAX is expected to be the next generation for mobile communication and wireless Internet access. To attract new WiMAX subscribers, KT offered a six month of free WiMAX services or other promotions such as free netbooks for WiMAX subscribers. However, after the six months or the contract period, many users were not resubscribing to WiMAX service and switched to alternative Internet access services [24] such as wired high-speed Internet. There are several wired and mobile Internet access services. The low continuance rate of these users is a concern, because it directly impacts the performance of the mobile Internet service providers [20]. It has been studied that it costs five times more to acquire a new customer than to retain an existing one [12]. There is thus an impelling motivation for mobile Internet service providers to enhance the continuance of their service users.

However, most previous research on IS continuance [6] [23] [21] [35] focused on the technology user perspective. From this perspective, the technology attributes (e.g., usefulness) together with the user experience with the technology (e.g., satisfaction) are the most important factors in determining the user’s continuance decision [6]. WiMAX users, however, have dual roles, technology user and WiMAX service consumer. WiMAX users have to pay for the use of WiMAX services. Rational economic assessment is essential for consumer decision makings [34] [37]. There has been lack of consideration about rational economic assessment in previous research on IS continuance including the IS continuance model [6].

This study thus aims to examine IS continuance by adding the rational economic assessment from the service consumer perspective to the IS continuance model in the context of WiMAX. Marketing [34] [37] and economics [18] literature explain two assessments in consumer decision makings: value and comparison with alternatives. Value refers to the net benefits of target based on the comparison between benefits and costs [37]. Service consumers further compare between alternatives and choose better one in their decision makings [18] [34]. For the model of rational economic assessment, this study adopts the customer value theory [37] together with alternative comparisons [17]. The contributions of this study includes the theoretical advancement of IS continuance model. The findings also provide suggestions for WiMAX service providers regarding how to retain their WiMAX users.

The rest of the paper is organized as follows. The next section presents the conceptual background of this research. This is followed by the research model and hypotheses. We then describe the research methodology. After interpreting the empirical results, we discuss the theoretical and practical implications and conclude with a summary of this study.

CONCEPTUAL BACKGROUND

WiMAX and Alternatives

WiMAX is conceptualized as a wherever, whenever service available for mobile devices that connect to a high-speed wireless Internet during movement. WiMAX overlaps its position with other Internet services [27] [1]. When compared to Wideband Code Division Multiplex Access (WCDMA) and High Speed Downlink Packet Access (HSPDA) services, WiMAX’s mobility and accessibility are relatively lower but its speed in transmitting big size data such as video file is relatively higher. That is, the download speed of WiMAX is
up to 24.8 Mbps (5.2 Mbps for upload) while that of HSDPA is up to 14.4 Mbps (2 Mbps for upload). HSDPA enables users to access Internet even when they are moving at speeds up to 250 km/h. Because W-CDMA and HSDPA are mainly used for Internet connection for cell phones or smart phones, it is installed in most smart phones as a basic function. In contrast, WiMAX is used not only for cell phones but also other mobile devices. Mobile devices and laptop computers require additional device (i.e., USB dongles) for the Internet connection through WiMAX. However, the usage fee of WCDMA and HSDPA is higher than WiMAX.

Compared to WiMAX, wireless LAN including Wi-Fi and wired-high speed Internet are limited by their mobility and usage coverage. Especially, wired high-speed Internet has no mobility although its speed in transmitting data including video is faster than other alternatives. Similarly, wireless LAN’s data transmission speed (up to 600 Mbps) is faster than WiMAX. People can use wireless LAN for free in many cases. However, Wi-Fi users can access to the Internet within 120 meters from the nearest access point while WiMAX users can access within 1 kilometer from the nearest radio access station. For this reason, WiMAX is better than Wireless LAN in terms of accessibility. The service coverage of wireless LAN is relatively limited. WiMAX overcomes market limitations of existing mobile communication services by securing economic competitiveness and offering the same level of Internet access environment as fixed Internet service to various mobile devices including dongles (i.e., wireless broadband adapters). Because WiMAX offers Internet connection freely without reprocess contents, it opened a substantial combination of wire-wireless services, commercialized for the first time in Korea in 2006. It obtained 239,000 subscribers in July 2009 [25]. At that moment, WiMAX services were mainly focused on mobile Internet access, rather than content. Strong sales of the WiMAX service was delayed due to the narrow service coverage, limited device selection, and early reliability issues. Currently, WiMAX offers Internet access and data transmission services. Smartphones, dongles, WiMAX phones, mobile PCs, and PMP access services are offered by service providers with over 95% being smartphones and dongles. Today, the WiMAX service has extended its coverage nationwide in Korea, promoted new customers with a flat-rate, integrated with other Internet service providers and launched various mobile devices. As a result, subscribers of WiMAX have increased steadily from the 3rd quarter of 2007. Among those various reasons, it was analyzed that the flat-rate charge and the free dongles proved to increase the number of subscribers. However, its commercialization is still at the beginning stage.

WiMAX is known as Mobile WiMAX worldwide and is used in 27 nations with 2.3GHz (in US, Singapore, Australia and Korea) and 2.6GHz (in US, Netherlands, Japan, and Taiwan) bandwidth. WiMAX is also selected as an international standard of 3rd generation (3G) mobile communication. Another advantage of WiMAX is that it uses the IP networks as its way of communication. Unlike wireless LAN, WiMAX overcomes the limitation of mobility. When we use a mobile phone network, it is hard to avoid the expensive fees. The WiMAX service can reduce these limitations by preempting the next mobile communication market. It does this by integrating all IP networks with other mobile network systems and offer various services. WiMAX is also the most ideal service to develop high speed Internet service in developing countries for its wireless properties. Commitment.

**Conceptual Framework**

Because WiMAX users have double roles of technology user and service consumer, this study suggests an extension of the IS continuance model [6] by adding rational economic assessment of service consumers. IS continuance model has focused on explaining an individual user’s continued usage of technology from the technology user perspective. The IS continuance model suggests that users’ continuance intention is determined by user satisfaction and perceived usefulness of target technology. User satisfaction, in turn, is influenced by their confirmation of expectation from prior IS use and perceived usefulness. Perceived usefulness is influenced by users' confirmation level.

Based on the IS continuance model, there have been several research on the technology continuance. Most previous research examined several antecedents of IS continuance mainly from the technology user perspective and identified technology factors (e.g., perceived usefulness) and user experience with technology (e.g., satisfaction) as main antecedents of IS continuance (See Appendix1). Missing in previous research on IS continuance is the assessment of target technology from the rational economic perspective as a service consumer or buyer. Rational economic buyers are characterized by the value assessment of target [37] and the comparison between target and alternatives [17] [18] [34]. It is known customers are value-driven and they make a decision, i.e., choose one with higher attractiveness than alternatives [34].

Regarding value assessment, value means net benefits of target based on the comparison between benefits and costs [22] [37]. There are financial and non-financial benefits and costs. Previous research [20] shows that perceived value is a key determinant of mobile Internet service adoption by developing the Value based Adoption Model (VAM). In the context of mobile Internet services, benefits include usefulness and enjoyment while costs include fee for the service use and technicality [20]. In addition to value assessment, customers choose the one that offers higher utility than alternatives [34]. If the level of alternative attractiveness is higher than the target object, customers may not be willing to choose the target one. In the context of Internet access services, there are several alternatives including WiMAX as discussed before.

This study considers both rational economic perspective and technology user perspective in examining the antecedents of technology service continuance, i.e., WiMAX continuance. From the technology user perspective, this study selects perceived usefulness and satisfaction as the antecedents. From the rational economic perspective, this study selects perceived value and attractiveness of alternatives as the antecedents of technology service continuance.

**RESEARCH MODEL AND HYPOTHESES**

Based on the conceptual framework, we propose the research model presented in Figure 1.
From the technological user perspective, the IS continuance model [6] explains perceived usefulness, confirmation, and satisfaction as direct or indirect antecedents of WiMAX continuance intention. From the rational economic perspective, the VAM [21] explains perceived value, which is influenced by benefit factor (i.e., perceived usefulness) and cost factors (perceived fee and technicality), as a direct antecedent of WiMAX continuance intention. Because WiMAX is rather cognitive technology by mainly supporting Internet access (not contents) rather than hedonic one, we exclude enjoyment from the research model although the VAM includes enjoyment as a benefit factor. From the additional rational economic perspective, we suggest attractiveness of alternatives as another direct antecedent of WiMAX continuance intention.

ISH1: Satisfaction has a positive effect on WiMAX continuance intention
ISH2: Perceived usefulness has a positive effect on WiMAX continuance intention
ISH3: Perceived usefulness has a positive effect on satisfaction
ISH4: Confirmation has a positive effect on satisfaction
ISH5: Confirmation has a positive effect on perceived usefulness

Zeithaml [37] explains that customers perceive what is received and what is given and then determine overall assessment of the utility (i.e., value) of target product or service. Perceived value thus refers to a consumer’s overall perception of WiMAX based on the considerations of its benefits and sacrifices needed to use it. Following previous research [20] [37], we define perceived value as a net benefit (perceived benefit via sacrifice) of the WiMAX service. Service users try to maximize its utility and value in their decision makings and behaviors as part of a rational decision making process [34] [37]. For this reason, if the WiMAX service produces high value then the service users may want to continue using the service.

**H6: Perceived value has a positive effect on WiMAX continuance intention**

Rational economic decision makers assess not only the value of the target service but also its relative attractiveness in comparison with other alternatives [34]. Attractiveness of alternatives refers to “customer perceptions regarding the extent to which viable competing alternatives are available in the marketplace” [17]. Alternative attractiveness is conceptualized as the client’s estimate of the likely satisfaction available in an alternative [30]. Attractiveness of alternatives thus means customer perception regarding the extent to which alternative Internet access services are more attractive than WiMAX service. There are several Internet access services (e.g., WCDMA/HSDPA, Wireless LAN, and Wired high speed Internet) other than WiMAX as we discussed before. WiMAX and other Internet services have different market positions in terms of fee, coverage and speed but they have ambiguous borders in market position due to well developed wire and wireless Internet service environment. For this reason, customer’s comparative recognition in substitutes of WiMAX can affect the WiMAX continuance negatively. If alternatives have relative advantage in using Internet access services compared to WiMAX, users may switch to the attractive alternatives. In contrast, a lack of attractive alternative has been suggested to be a favorable situation to defend clients [30]. That is, relative advantage of target technology may influence the usage and continuance of the technology [19]. Attractiveness of alternatives may thus disturb the continuance of WiMAX negatively.

**H7: Attractiveness of alternatives has a negative effect on WiMAX continuance intention**

Satisfaction is considered as emotional response [8] [28]. Cognitive-evaluative process triggers satisfaction as emotional response [29]. Perceived value as a cognitive factor has rational structure to understand the discordance of benefit-sacrifice. Self-control process [3] and emotion/adaption theory [26] explain rational perception and assessment (i.e., perceived value) leads to the emotional responses (i.e., satisfaction). Perceived value of WiMAX service may thus affect user satisfaction with the service.

**H8: Perceived value has a positive effect on satisfaction**

Attractiveness of alternative Internet access services can be increased as the value (i.e., net benefits) of alternatives increases or as the value of target WiMAX service decreases. For example, if alternative Internet access services are available with higher value (e.g., lower cost, high performance, and greater convenience) then the attractiveness of WiMAX service would be lowered. In contrast, high value of WiMAX service may increase the attractiveness of the service which may, in turn, lower attractiveness of alternatives. Similarly, if users are satisfied with WiMAX service, they may perceive high level of attractiveness of the service, which may in turn lower attractiveness of alternatives. Perceived value and satisfaction are cognitive assessment and emotional assessment of the target WiMAX service respectively without comparison with alternatives. These two cognitive and emotional assessments may thus affect relative...
This study identified two sacrifice factors and one benefit factor as the antecedents of perceived value. As a sacrifice factor, technicality means the degree to which WiMAX is perceived as being technically excellent in the process of providing services [20]. As the level of technicality decreases, WiMAX users have to sacrifice their time and efforts more in using WiMAX service. In contrast, as the level of technicality increases, the users would be able to spend less time and efforts in using the service. Technicality thus may affect overall value perception [20].

As another sacrifice factor, this study identifies perceived fee. Perceived fee symbolizes the encoding or internalization of the objective usage fee of service. The fee structure of WiMAX consists of the pay-as-you-use scheme and subscription-based pricing. Jacoby and Olson [16] distinguish between the objective price and the price encoded by customers (i.e., perceived price). Customers usually do not remember the objective price [37]. Instead of having perfect information about prices, customers possess internal reference prices and make comparison with these prices [11]. They encode prices in ways meaningful to them, whose outcomes drive the price perception of customers [16]. In the case of WiMAX service, customers would probably compare the fee with other reference prices such as the usage fee of alternative Internet access services and encode the fee as high or low. As the perceived fee increases, the overall value of WiMAX service may decrease. Perceived fee may thus reduce perceived value [20].

Perceived usefulness has long been identified as a key benefit factor motivating the adoption and continuance of technology [6]. In addition to the direct effect of perceived usefulness, we propose the indirect effect of perceived usefulness on continuance through overall value assessment. There are several benefit factors i.e., job-fit, outcome expectations, relative advantage, extrinsic motivation, and performance expectancy [36]. Because overall value (i.e., perceived value) is assessed based on the comparison between benefits and costs, benefit factors affect the value perception. Perceived usefulness of WiMAX service may thus increase overall value of WiMAX service [20].

H11: Technicality has a positive effect on perceived value
H12: Perceived fee has a negative effect on perceived value
H13: Perceived usefulness has a positive effect on perceived value

RESEARCH METHODOLOGY

Data empirically validate the research model of Figure 3 were collected through a field survey using a questionnaire. We also collected qualitative data by conducting interviews with 20 WiMAX users and 2 industry experts. According to the interview results, people adopt WiMAX because of its several benefits such as mobility, convenience, and low fee. They also mentioned limitations of WiMAX such as accessibility to WiMAX at some places, low speed in playing video files, and additional USB modem for the Internet access. Compared to alternative Internet access services, interviewees mentioned lower speed than wired Internet access services and limited coverage but more convenience compared to wireless Internet access services. The interviews also assisted in the interpretation of specific survey results.

Instrument Development

To develop the survey instrument, we adopted existing validated scales wherever possible. We adapted the items for WiMAX continuance intention, satisfaction, perceived usefulness, and confirmation from Bhattacherjee [6] by considering the WiMAX service context. We also adapted the items for perceived value, technicality, and perceived fee from Kim et al. [20]. To assess attractiveness of alternatives, we adapted scales from Jones et al. [17]. Alternatives in this study mean other Internet access services than WiMAX. The construct of technicality is considered formative because it is a composite of multiple indicators. In contrast, the other constructs are considered reflective because they are each uni-dimensional and exclusion of an indicator does not alter the construct’s meaning.

Two IS researchers reviewed the instrument for its face validity. Feedbacks on the questionnaire also were obtained from five WiMAX users with regard to any ambiguity of the questions, the length of the instrument, the format of the scales, and the information to be sought from respondents. The final measurement items are presented in the Appendix 2. All measurement items were anchored on the seven-point Likert scale (1=strongly disagree, 7=strongly agree).

Data Collection

We selected KT as the context of our study because it is a successful WiMAX service provider in the Korean market. Although WiMAX service providers such as Clear in the U.S., iBurst in South Africa or Aria in Italy, are similar international mobile Internet service providers, KT gives us more distinct comparativeness to other Internet service providers due to the well saturated Korean market. With the help from the marketing manager of KT, we randomly selected 800 WiMAX subscribers and invited for the survey. E-mails were sent out via KT WiMAX to the selected subscribers. We explained the purpose of this research and the contents of the survey.

A total 202 responses were collected over two weeks. After dropping two incomplete responses, 200 responses were used for data testing (see Table 1). The respondents have used the WiMAX Internet services for 16.13 months on average. They have used the services in different level of frequencies: more than 10 times a day (5.0%), between 1-9 times per day (44.5%), 1-6 times per week (40.5%), 1-3 times per month (6.0%), and less than 1 time per month (4.0%). Most respondents are professionals (84.0%) in thirties (28.5%) and fourties (43.0%).
Results of the structural model assessment showed multicollinearity among the constructs. The correlations between the constructs were examined, and the results did not indicate any construct-factor correlation exceeding 0.5. The convergent validity for the constructs was supported as the variance extracted (AVE) for each construct was greater than 0.5. Cronbach’s α for all constructs exceeded 0.7. The average variance extracted was calculated using the square root of the AVE, which indicates discriminant validity. As shown in Table 2, the square root of AVE for each construct (diagonal term) exceeded the correlations between the construct and other constructs. Hence, discriminant validity of the instruments was supported.

DATA ANALYSIS AND RESULTS

Instrument Validation

We carried out data analysis in accordance with a two-stage methodology [2]. PLS was chosen for the data analysis because it can account for structural models with both formative and reflective constructs [7]. To validate the survey instrument, we performed confirmatory factor analysis. We first assessed convergent and discriminant validity of the constructs. For the formative construct (i.e., technicality), absolute item weights were checked to determine the relative contribution of items constituting the construct [7]. All items with standardized loadings greater than 0.7 were significant at the 0.05 level. Multicollinearity among the indicators of technicality was also assessed by calculating variance inflation factor. The results did not indicate any problem.

As for the other reflective constructs, the standard path loadings were all significant (t-value > 1.96) and greater than 0.7 (See Table 2). The Composite Reliability (CR) and Cronbach’s α for all constructs exceeded 0.7. The average variance extracted (AVE) for each construct was greater than 0.5. The convergent validity for the constructs was supported.

We then assessed the discriminant validity of the measurement model by comparing the square root AVE for each construct with the correlations between the construct and other constructs. If the square root of AVE is greater than the correlations between the construct and other constructs then it indicates the discriminant validity [10]. As shown in the Appendix 3, the square root of AVE for each construct (diagonal term) exceeded the correlations between the construct and other constructs. Hence, discriminant validity of the instruments was supported.

We tested for multicollinearity among constructs. In all cases, the variance inflation factor was below 10 and condition index was less than 30, indicating that multicollinearity is not likely to distort testing results in our study [13]. We also tested our data for common method variance using the Harman’s single-factor test [14]. The threat of common method bias is high if a single factor accounts for more than 50 percent of the variance. Results of the test indicate that our data do not suffer from common method variance.

Hypotheses Testing

We tested the hypotheses by applying the bootstrapping re-sampling technique. Results of the structural model analysis are shown in Figure 2. Satisfaction (H1) and attractiveness of alternatives (H7) were found to have significant effects on WiMAX continuance intention, explaining 54 percent of its variance. Technicality (H11), perceived fee (H12), and perceived usefulness (H13) were found to have significant effects on perceived value.

### Table 1. Descriptive statistics of respondents

<table>
<thead>
<tr>
<th>Demographic variable</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>155</td>
<td>77.50</td>
</tr>
<tr>
<td>Female</td>
<td>45</td>
<td>22.50</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-19</td>
<td>1</td>
<td>0.50</td>
</tr>
<tr>
<td>20-29</td>
<td>32</td>
<td>16.00</td>
</tr>
<tr>
<td>30-39</td>
<td>57</td>
<td>28.50</td>
</tr>
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<td>86</td>
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</tr>
<tr>
<td>50-59</td>
<td>24</td>
<td>12.00</td>
</tr>
<tr>
<td>Job</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student</td>
<td>26</td>
<td>13.00</td>
</tr>
<tr>
<td>Professional</td>
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<td>84.00</td>
</tr>
<tr>
<td>Housewife</td>
<td>3</td>
<td>1.50</td>
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<td>Others</td>
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</tr>
<tr>
<td>Total</td>
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</tr>
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</table>

Table 2. Psychometric Properties of Reflective Constructs

<table>
<thead>
<tr>
<th>Construct</th>
<th>Item</th>
<th>Std. Loading</th>
<th>AVE</th>
<th>CR</th>
<th>Cronbach’s alpha</th>
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<td>0.89</td>
<td>0.96</td>
<td>0.94</td>
</tr>
<tr>
<td></td>
<td>TEE2</td>
<td>0.95</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TEE3</td>
<td>0.97</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VAL</td>
<td>VAL1</td>
<td>0.85</td>
<td>0.85</td>
<td>0.96</td>
<td>0.96</td>
</tr>
<tr>
<td></td>
<td>VAL2</td>
<td>0.96</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>VAL3</td>
<td>0.95</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>VAL4</td>
<td>0.92</td>
<td></td>
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<td></td>
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<tr>
<td>USF</td>
<td>USF1</td>
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<td>0.91</td>
<td>0.98</td>
<td>0.96</td>
</tr>
<tr>
<td></td>
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<td>0.95</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>USF3</td>
<td>0.96</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>USF4</td>
<td>0.97</td>
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<tr>
<td>CNF</td>
<td>CNF1</td>
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<td>0.93</td>
<td>0.97</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td>CNF2</td>
<td>0.97</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CNF3</td>
<td>0.96</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAT</td>
<td>SAT1</td>
<td>0.91</td>
<td>0.87</td>
<td>0.97</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td>SAT2</td>
<td>0.96</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SAT3</td>
<td>0.95</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SAT4</td>
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<td></td>
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<tr>
<td>ATT</td>
<td>ATT1</td>
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<td>0.88</td>
<td>0.96</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td>ATT2</td>
<td>0.94</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ATT3</td>
<td>0.96</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CNT</td>
<td>CNT1</td>
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<td>0.90</td>
<td>0.97</td>
<td>0.93</td>
</tr>
<tr>
<td></td>
<td>CNT2</td>
<td>0.95</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CNT3</td>
<td>0.93</td>
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</tbody>
</table>
explaining 69 percent of its variance. Perceived value (H8) and confirmation (H4) were found to have significant effects on satisfaction, explaining 51 percent of its variance. Confirmation (H4) also was found to have a significant effect on perceived usefulness, explaining 42 percent of its variance. However, we could not find significant direct effects of perceived value (H6) and perceived usefulness (H2) on WiMAX continuance intention. We also could not find a significant direct effect of perceived usefulness (H3) on satisfaction.

We further tested whether the effect of perceived value on WiMAX continuance intention is mediated by satisfaction following the guidelines suggested by Baron and Kenny [4]. Perceived value has a significant effect on the continuance (path coefficient = 0.21, t = 2.28) when satisfaction was removed from the structural model. The effect, however, becomes insignificant when satisfaction was added to the model as in Figure 2. The effect of perceived value on the continuance is therefore fully mediated by satisfaction.

**Figure 2. Structural Model Testing Results**

(\*: p < 0.05, **: p < 0.01, ***: p < 0.001, ns: insignificant at the 0.05 level)

**DISCUSSION**

**Discussion of findings**

This research resulted in several salient findings. The key finding in this study is the significant antecedent of WiMAX continuance from the rational economic perspective. The findings show the significant effect of attractiveness of alternatives on the continuance intention. Internet service provider market is already saturated in Korea by many Internet access services including wired and wireless Internet access services. As a service consumer, Internet access service users may compare alternatives and choose or switch to a better choice. Even the current WiMAX users may discontinue the use of WiMAX service if they perceive relatively higher attractiveness of alternatives in comparison with WiMAX service. Similar to this finding, Jones et al. [17] explained that lower attractiveness of competing alternatives is associated with higher repurchase intentions in their marketing research. Many interviewees have ideas that there are several approaches for Internet access, wired or wireless. One interview mentioned that: “there is little special relative attractiveness of WiMAX compared to other Internet access services.” The other interviewee noted that: “I can use wire and wireless LAN to access to the Internet. I do not have any needs of the WiMAX service.”

This study also found the significant antecedent of WiMAX continuance from the technology user perspective. As Bhattacherjee [6] explained in his IS continuance model, the findings show the significant effect of user satisfaction on the continuance intention. Similarly, it is known that customer satisfaction is a key determinant of customer retention in marketing literature [31]. However, this study could not find the significant effect of perceived usefulness on WiMAX service intention, which is in conflict with the IS continuance model [6]. The post-hoc analysis shows the effect of perceived usefulness is fully mediated by perceived value. When we drop the relationship between perceived value and WiMAX continuance intention, perceived usefulness becomes to have a significant effect on the continuance intention (path coefficient = 0.17, t = 2.56). Perceived usefulness is a cognitive belief while perceived value is a cognitive overall assessment (i.e., net benefits). It seems that all three beliefs (i.e., perceived usefulness, perceived fee, and technicality) are captured in the cognitive overall assessment, perceived value. Similarly, this study could not find a significant effect of perceived usefulness on satisfaction, which is in conflict with the IS continuance model. The post-hoc analysis shows the effect of perceived usefulness on satisfaction is fully mediated by perceived value. When we drop the relationship between perceived value and satisfaction, perceived usefulness becomes to have a significant effect on satisfaction (path coefficient = 0.22, t = 2.89).

The significant effect of perceived value on satisfaction is in line with self-control process [3] and emotion/adaption theory [26]. However, this study could not find the significant effect of perceived value on the continuance intention directly while perceived value has been identified as a key determinant of mobile Internet service adoption [20]. Similarly, interviewees noted the importance of value in the adoption of WiMAX by mentioning that: “when I decide the adoption of WiMAX, the cost-benefit analysis is important.
for the decision making.” They noted the different importance of value in their continuance decision making by mentioning that: “while the cost-benefit analysis is important for the first decision making, it is not so important when I decide to continue using the WiMAX or.”

Instead, the findings show the indirect effect of perceived value through satisfaction. Value is cognitive assessment [20] [37] while satisfaction is emotional response or affective assessment [9] [28]. This is an interesting finding because many companies adopt emotion marketing these days. Although rationality (i.e., perceived value) as cognitive response affects emotion (i.e., satisfaction) as affective response, the findings could not find the direct relationship between cognitive response and WiMAX continuance intention while affective response has a directly significant effect on the intention. This finding supports the importance of emotion marketing [32].

The findings of this study, however, should be interpreted in the context of its limitations. First, this study has been conducted based on data and observations from a single nation, South Korea. More research is needed to examine the robustness and generalizability of the findings across the diverse context. Second, this study was conducted based on cross-sectional data. Future study can adopt a longitudinal study and test the model across stage from adoption and post-adoption. Next, the findings are mainly based on the perception data. Future study can use objective data as well as perception data in developing and testing the research model.

Implications for Research

There are several implications for research. First, this study adds to the previous research on IS continuance by explaining the significant role of attractiveness of alternatives in determining IS continuance. Previous research has explained the significant effects of the perceived characteristics of target technology or user experience with target technology on IS continuance such as perceived usefulness [6], perceived ease of use [23], perceived enjoyment [35], pleasure [20], self-efficacy [15], attitude [19], satisfaction [6]. There has been little research on the effect of comparison with alternatives on the technology continuance. This study is the first one showing the significant effect of attractiveness of alternatives on IS continuance.

Second, this study has adopted the theoretical background of consumer decision makings [34] [37] in examining IS continuance. Most previous research (e.g., [6] [15] [35]) has adopted the expectation-confirmation theory or theory of planned behaviour in examining IS continuance by taking the technology user viewpoint. According to consumer decision making models [34] [37], consumers evaluate net benefits (i.e., cost-benefit analysis) and compare the net benefits with alternatives in their decision makings. The WiMAX users have dual roles, technology users and service consumers. This study thus has a contribution in combining the viewpoints from technology user and service consumer in examining IS continuance.

Next, this study shows different roles of cognitive assessment (i.e., perceived value) and affective assessment (i.e., satisfaction) in IS continuance. This study found a significant role of satisfaction as affective assessment in determining IS continuance directly. This study also found a significant role of perceived value as cognitive assessment in mediating the effects of cognitive beliefs (e.g., perceived usefulness) and affecting user satisfaction. The post-hoc analysis shows that satisfaction fully mediates the effect of perceived value on the continuance intention and the effect of perceived value on attractiveness of alternatives.

Implications for Practice

There are also several implications for practice. Because WiMAX is the first commercialized 3G mobile Internet service, there are very little studies and researches that show real evidence or data about WiMAX service and continuance usage. Based on the findings in this study, WiMAX service providers can make a strong strategy in launching and continuing their service to their users. First, the findings explain the important role of attractiveness of alternativeness. That is, retaining relative attractiveness in comparison with alternatives is important in increasing WiMAX continuance, especially in the well developed telecommunication environment. There are several Internet access services with different characteristics as discussed in the conceptual background. Users may choose one or multiple Internet access services depending on their needs. One interviewee noted that “there are lots of Internet service vacant areas with WiMAX.” The other interviewee complained that “the speed of WiMAX is slower than other Internet access services.” Regarding the continuance of WiMAX, some interviewees commented that “if we can use all Internet access services with one equipment” and “with wider service coverage” and “if the disconnection problems are solved with higher speed,” “we may highly use WiMAX.” To grasp the continuance usage in WiMAX services, it is important to make easier Internet access and higher service quality, solving the disconnecting problems, and broadening service coverage. Internet service providers also can consider developing bundling package with multiple Internet access services. Currently, those alternatives for Internet access are considered as being competing each other. They can, however, complement each other depending on the user’s needs, tasks, and location.

Next, this study highlights user satisfaction and emotional marketing in WiMAX continuance. According to the interview with the industry experts, KT has focused on improving the technical quality and service fee for promoting WiMAX. In contrast, the findings explain the necessity of emotional marketing. As a way for emotional marketing strategies, enhancing user satisfaction should be a key element. This study explains that user satisfaction can be improved by net benefits of WiMAX service. Thus, it is important to increase the value by improving the usefulness of WiMAX service, enhancing the technicality, and lowering the WiMAX usage fee. It is helpful to maintain standard monthly fee that customers can accept and to subsidize Internet devices such as netbooks or smartphones.

CONCLUSION

Many technology users including WiMAX have dual roles, technology user and service consumer. Most previous research on IS continuance focused on identifying the key characteristics of target technology and user experience with it in identifying the antecedents of IS continuance. Little
research has considered rational economic assessment from the service consumer perspective in examining IS continuance. Two key elements in service consumer decision makings are value assessment and the comparison with alternatives. Going beyond previous research on IS continuance, as a key contribution, this study examined IS continuance by combining rational economic viewpoint and technology user viewpoint in the context of WiMAX. Especially, the findings of this study highlight the importance relative attractiveness of target technology (i.e., attractiveness of alternatives) and emotional marketing (i.e., user satisfaction) in promoting IS continuance. This study also provides several implications for Internet access service providers regarding how to retain WiMAX users.

### APPENDIX 1: SUMMARY OF PREVIOUS RESEARCH ON IS CONTINUANCE

<table>
<thead>
<tr>
<th>Researcher</th>
<th>Context</th>
<th>Background Theory</th>
<th>IS continuance factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bhattacherjee(2001a)</td>
<td>Online brokerage</td>
<td>Expectation-confirmation theory</td>
<td>Perceived usefulness, satisfaction, and the interaction between perceived usefulness and the loyalty incentives</td>
</tr>
<tr>
<td>Bhattacherjee(2001b)</td>
<td>Online banking</td>
<td>Expectation-confirmation theory</td>
<td>Perceived usefulness and satisfaction</td>
</tr>
<tr>
<td>Karahanna et al.(1999)</td>
<td>Microsoft’s Windows 3.1 software package</td>
<td>Theory of reasoned action</td>
<td>Attitude toward using the IS and perceived voluntariness</td>
</tr>
<tr>
<td>Kim &amp; Malhotra(2005)</td>
<td>Personalized portal website of a university</td>
<td>Technology adoption model</td>
<td>Perceived usefulness, perceived ease of use, and past use</td>
</tr>
<tr>
<td>Kim et al.(2007)</td>
<td>M-Internet service</td>
<td></td>
<td>Usefulness, attitude, and pleasure</td>
</tr>
<tr>
<td>Roca et al.(2006)</td>
<td>E-learning service</td>
<td>Expectation-confirmation theory</td>
<td>Satisfaction</td>
</tr>
<tr>
<td>Thong et al.(2006)</td>
<td>M-Internet service</td>
<td>Expectation-confirmation theory</td>
<td>Perceived usefulness, perceived ease of use, satisfaction, and perceived enjoyment</td>
</tr>
</tbody>
</table>

### APPENDIX 2: MEASUREMENT INSTRUMENT

<table>
<thead>
<tr>
<th>Variable</th>
<th>Item</th>
<th>Wording</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technicality (TEC)</td>
<td>TEC1</td>
<td>It is easy to use WiMAX.</td>
<td>Kim et al. (2007)</td>
</tr>
<tr>
<td></td>
<td>TEC2</td>
<td>WiMAX has no disconnection during usage.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TEC3</td>
<td>WiMAX takes a short time to respond.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TEC4</td>
<td>WiMAX is anytime available.</td>
<td></td>
</tr>
<tr>
<td>Perceived fee (FEE)</td>
<td>FEE1</td>
<td>The fee that I have to pay for the use of WiMAX is too high.</td>
<td>Kim et al. (2007)</td>
</tr>
<tr>
<td></td>
<td>FEE2</td>
<td>The fee that I have to pay for the use of WiMAX is reasonable (reversed).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FEE3</td>
<td>I am pleased with the fee that I have to pay for the use of WiMAX (reversed).</td>
<td></td>
</tr>
<tr>
<td>Perceived Value (VAL)</td>
<td>VAL1</td>
<td>Considering the fee I need to pay, the use of WiMAX offers value for money.</td>
<td>Kim et al. (2007)</td>
</tr>
<tr>
<td></td>
<td>VAL2</td>
<td>Considering the effort I need to put in, the use of WiMAX is beneficial to me.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VAL3</td>
<td>Considering the time I need to spend, the use of WiMAX is worthwhile to me.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VAL4</td>
<td>Overall, the use of WiMAX delivers me good value.</td>
<td></td>
</tr>
<tr>
<td>Confirmation (CFM)</td>
<td>CFM1</td>
<td>My experience with using WiMAX was better than what I expected.</td>
<td>Bhattacherjee (2001b)</td>
</tr>
<tr>
<td></td>
<td>CFM2</td>
<td>The service level provided by WiMAX was better than what I expected.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CFM3</td>
<td>Overall, most of my expectations from using WiMAX were confirmed.</td>
<td></td>
</tr>
<tr>
<td>Perceived USF1</td>
<td>USF1</td>
<td>Using WiMAX improves my performance in doing what I want.</td>
<td>Bhattacherjee (2001b)</td>
</tr>
</tbody>
</table>
usefulness (USF)  | USF2  | Using WiMAX enhances my effectiveness in doing what I want.  
|-------|------|--------------------------------------------------|
|       | USF3  | Overall, WiMAX is useful in performing what I want.  

Satisfaction (SAT)  | SAT1  | Very dissatisfied/Very satisfied  
|-------|------|--------------------------------------------------|
|       | SAT2  | Very displeased/Very pleased  
|       | SAT3  | Very frustrated/Very contented  
|       | SAT4  | Absolutely terrible/Absolutely delighted  

WiMAX Continuance intention (CNT)  | CNT1  | I intend to continue using WiMAX rather than discontinue its use.  
|-------|------|--------------------------------------------------|
|       | CNT2  | My intentions are to continue using WiMAX than use any alternative Internet access services.  
|       | CNT3  | If I could, I would like to discontinue my use of WiMAX (reverse coded).  

Attractiveness of Alternatives (ATTT)  | ATT1  | If I needed to change Internet access services, there are other good services to choose from.  
|-------|------|--------------------------------------------------|
|       | ATT2  | I would probably be happy with other Internet access services than WiMAX.  
|       | ATT3  | Compared to WiMAX, there are other Internet access services with which I would probably be equally or more satisfied.  

Bhattacherjee (2001b)  
Bhattacherjee (2001b)  
Jones et al. (2000)  

### APPENDIX3: CORRELATIONS BETWEEN LATENT CONSTRUCTS

<table>
<thead>
<tr>
<th>Mean</th>
<th>SD</th>
<th>CNT</th>
<th>SAT</th>
<th>VAL</th>
<th>REL</th>
<th>TEC</th>
<th>FEE</th>
<th>USF</th>
<th>CNF</th>
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<tr>
<td>CNT</td>
<td>4.63</td>
<td>1.44</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAT</td>
<td>4.54</td>
<td>1.23</td>
<td>0.44</td>
<td>0.93</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VAL</td>
<td>4.75</td>
<td>1.29</td>
<td>0.40</td>
<td>0.62</td>
<td>0.92</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATT</td>
<td>3.95</td>
<td>1.50</td>
<td>-0.66</td>
<td>-0.27</td>
<td>-0.18</td>
<td>0.94</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEC</td>
<td>4.54</td>
<td>1.18</td>
<td>0.34</td>
<td>0.66</td>
<td>0.66</td>
<td>0.06</td>
<td>0.19</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>FEE</td>
<td>3.59</td>
<td>1.36</td>
<td>-0.21</td>
<td>-0.33</td>
<td>-0.50</td>
<td>-0.16</td>
<td>0.16</td>
<td>-0.30</td>
<td>0.94</td>
</tr>
<tr>
<td>USF</td>
<td>4.87</td>
<td>1.24</td>
<td>0.37</td>
<td>0.57</td>
<td>0.78</td>
<td>-0.16</td>
<td>0.54</td>
<td>-0.34</td>
<td>0.95</td>
</tr>
<tr>
<td>CNF</td>
<td>4.46</td>
<td>1.39</td>
<td>0.46</td>
<td>0.68</td>
<td>0.68</td>
<td>-0.22</td>
<td>0.68</td>
<td>-0.33</td>
<td>0.65</td>
</tr>
</tbody>
</table>

(Note: Leading diagonal shows the squared root of AVE of each construct. AVE is not calculated for formative construct)

### REFERENCES (BIBLIOGRAPHY)


ABSTRACT

Technological innovations have become strategic catalysts to maintaining sustainable growth in today’s global and competitive business environments. The evolutionary and dynamic innovation perspectives propose a dynamic relationship between diversification strategies and technological capabilities in technology-oriented multinational corporations (TMCs). This study attempts to empirically explore the strategic impacts of corporate diversification on technological innovation. The major findings of this study demonstrate that corporate diversification strategies in markets and products are significantly related to various indices of technological innovation and economic performance in multinational corporations across different country and industry sectors.

INTRODUCTION

Over the past decades, one of the most distinguishing features of the technology-oriented multinational corporations (referred hereafter as TMCs) has been the increased focus on technological innovations and sustained growth in a competitive global market. The globalization of Research and Development (R&D), as one of the major input factors in innovation, has also been one of the several driving forces in building a competitive edge in today's competitive and turbulent economic environment. Globalization has opened market opportunities to companies of diverse national origins, allowing them to offer a multitude of goods, products and services (Porter, 1998; Ravichandran, 2008; Chiang, 2010) to local customers. Global competition coupled with shorter product cycles, growing innovative capabilities, changing customer tastes have shortened product life cycles. TMCs, therefore, can no longer rely solely on economies of scale and scope to build strong global market positions and protect them from their rivals (Cantwell & Vertova, 2004; Ghoshal & Nohria, 1989). Due to intense global market competition and uncertainty, TMCs must continuously innovate to observe sustained growth, otherwise to embrace failure (Artz et al., 2010; Chari et al., 2008; Huang & Lin, 2006; Teece et al., 1997).

Technological innovation is the technical process through which new and/or improved technologies are developed and proliferated through commercialization (Ambj & Zwaan, 2006). In fact, technological innovation is the main reason for the existence and successful performance of modern enterprises in a competitive global market (Dedrick et al., 2003; Kogut, 1990). Innovation allows firms to develop capabilities that give them a competitive advantage over their rivals by introducing unique products, services, and even operational processes that may be hard for competitors to imitate. R&D activities also provide fundamental inputs to TMCs’ innovations, leading to patents and ultimately to new products (Anonymous, 1996; Hagedoorn & Cloodt, 2003). It is well recognized that R&D intensity can be referred to as one of the major determinants of a firm’s new product introduction (Soderquist & Godener, 2004), patent (Mukherjee & Ray, 2009), market share (Franko, 1989), export (Lee & Habte-Giorgis, 2004), foreign direct investments (Glass & Saggi, 1999; Kogut, 1990), and firm performance (Artz et al., 2010).

Technological innovations have also been known to drive diversification strategies in products and markets as a means of creating wealth for their shareholders. Diversified firms appear to be financially more profitable and are able to achieve a larger market share, domestically and globally. But such realized higher values are more likely to stem from increased innovation efficiency and higher level of R&D activities rather than from more efficient use of assets (Chiang, 2010; Ravichandran, 2008). In today’s uncertain market conditions due to intense competition, firms need to develop sustainable capabilities and strategies to help them navigate by diversifying products and markets (Chari et al., 2008; Hitt, et al., 1997). Whether and how corporate diversification strategies in products and markets, individually or combined, influence today’s technological innovations and capabilities, including R&D activities, are still unclear and inconclusive.

Although diversification strategies are motivated by different objectives, they might have differential effects on R&D intensity. If firms differ in their use of product and diversification internationally, then it would be prudent to investigate the interactive effects of these strategies on R&D intensity and their outcomes. Also, in conducting their analyses, researchers have used data primarily available at U.S.-based firms and/or a limited number of countries as well as industry segments. Thus, most studies have failed to establish the generalized effect of technological innovations and R&D capabilities on different dimensions of diversification in products and markets across countries.

Given the important role TMCs play in the international economy, researchers have sought to identify factors that determine their ability to innovate in global markets. Mounting evidences suggest that TMCs’ corporate strategies can stimulate their investments with a commitment to maintaining those technological capabilities required for profitable and continuous innovations (Hitt et al., 1997; Mohnen et al., 2006). Despite the importance of technological capabilities for profitable innovations (Miller, 2006; Patel & Pavitt, 1998),

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the strategic linkages between diversification and technological innovation as well as capabilities in the global perspectives are not well documented.

Furthermore, most prior research articles have ignored the effects of diversification strategies on the outcomes of R&D intensity including the development of new products and patents which are the sources of a high-tech firm’s competitive advantage (Dunning, 1998; Patel & Pavitt, 1997 & 1998; Porter 1998). Prior research also failed to recognize that TMCs differ significantly in their R&D capabilities and technological innovations to diversify markets as well as products (Chiesa, 1996). Some TMCs are also more efficient in managing their own R&D operations and therefore reap greater benefits from their investments. This suggests that diversification strategies may not affect R&D outcomes as much as spending. Consequently, the strategic impact of corporate diversification strategies, in both markets and products, on technological capabilities and innovations, need to be explored in a global context.

**RESEARCH QUESTIONS**

This study empirically explores the strategic impact of diversification activities on technological capabilities created by innovation and R&D intensity for TMCs that operate globally. More specifically, this study is primarily designed to focus on three major indicators of a firm’s technological innovation capabilities. The first is R&D intensity, which is a key source of technological innovation capabilities and how they are crucial for creating the knowledge flow necessary for product and process innovations (Hagedoorn & Cloodt, 2003). The dynamic capability and evolutionary perspectives propose that R&D investments are crucial to creating the knowledge—an intangible resource that TMCs can employ in their business operations. The second is the number of patents a firm hold, which is a key measure of innovative capacity of a firm as well as an important source of competitive advantage in global markets (Patel & Pavitt, 1991, 1997; Hagedoorn & Cloodt, 2003), and knowledge stocks (DeCaloris & Deeds, 1999). Patents indicate a firm’s success in discovery and innovation (Griliches, 1988; Hagedoorn & Cloodt, 2003) and represent a reliable proxy of a firm’s progress in developing strong technological capabilities (Narin, Noma & Perry 1993; Patel & Pavitt, 1998). Third, a new measure of innovation according to Business Week, called technological strength is a composite of the number of product patents and their citations reflecting on the quality of innovation.

In addition to the functional linkages between R&D and diversification at the subsidiary level (Almeida & Phene, 2004; Frost, 2001; Feinberg & Gupta, 2004), this study further examines the individual and interactive effects of international and product diversification strategies on TMCs’ future innovations (Ahuja & Katila, 2004; Frost, 2001; Hitt et al., 1994; Hitt et al., 1997). Given the importance of innovation for global success (Patel & Pavitt, 1997; Arzt et al., 2010), the effect of these strategies on TMCs’ innovation requires rigorous empirical investigations. Since international diversification brings new and perhaps different knowledge into the firm’s innovation process and enhances its ability to generate patents and, therefore, develop new products, researchers need to document these effects.

**Theoretical Foundation of the Study**

TMCs usually start their international operations by marketing products that have been developed in their R&D units and have been successful in their domestic market. Their successful performance is predicated on continuous and successful innovation strategies. TMCs compete by exploiting a combination of firm specific advantages which include ownership of intangible assets, location-specific advantages, and internalized transactions to achieve control over their foreign investments (Dunning, 1988). Intangible assets, such as technological capabilities, can give high-tech corporations competitive advantages over their rivals (Dunning, 1998; Shan & Song, 1997). TMCs can sustain these advantages only if they have technological capabilities that are rare, inimitable, and not substitutable (Barney, 1991). International market diversification (IMD) and product diversification (PD) can foster the accumulation of technological capabilities by exposing TMCs to different domestic and international business environments (Barkema & Vermeulen, 1998). It is also empirically demonstrated that the impact of technology innovation is greater for firms with higher levels of diversification than for those with lesser diversification (Chari et al., 2008; Shin, 2006).

**International Market Diversification (IMD) and Technological Innovation & Capabilities**

Several studies have demonstrated the growing internationalization of R&D activities in TMCs. In the Global Benchmark Survey of the strategic management of technology of the largest TMCs, Gerybadze (2004) reported six industries that are highly characterized by high foreign R&D. Multinational enterprises use IMD to achieve a variety of objectives, including the ability to enhance their shareholders’ wealth (Markides & Ittner, 1997). The organizational learning perspective (Huber, 1991) suggests that IMD can also enable TMCs to acquire new technological skills to augment their in-house R&D and other innovative capabilities (Chiesa, 1996; Kotabe, 1990). The organizational learning perspective also highlights the importance of the TMCs’ increased exposure and access to diverse knowledge and skills as IMD increases (Barkema & Vermeulen, 1998; Hitt et al., 1997). The diversity of markets and business environments can enhance the firms’ learning capabilities, and future innovations (Stata, 1989). Thus, international diversification induces organizational learning of new technology by broadening the TMCs’ geographic scope, giving them an opportunity to recoup their R&D investments and make a profit (Korbin, 1991). These skills can improve the TMCs’ capacity to innovate, thereby, increasing their future market values and enriching their shareholders wealth.

However, the TMCs’ ability to protect their markets depends largely on their success to create new products and services that meet local needs. Technology oriented firms, therefore, must successively generate radical innovations (Kogut, 1990). However, such radical
innovation is costly (Mansfield, 1988). International market diversification (IMD) stabilizes profits (Caves, 1982), creating slack resources needed for costly and radical innovations that improve firm responsiveness to local customers through product customization and original product developments (Kotabe, 1990). As production becomes more global, the need for appropriate knowledge derived from patents also increases. The internationalization of production leads to the internationalization of knowledge, which in turn, leads to true global integration in TMCs.

With the growing dispersion of technological knowledge, innovations frequently result from the interaction and cooperation of multiple organizations around the globe (Arora & Gambardella, 1990; Porter, 1998). These organizations usually have different resources and specialized knowledge bases. Technological knowledge is usually tacit in nature (Nonaka & Takeuchi, 1995) and therefore cannot be easily duplicated, transferred or efficiently separated from its context (Szulanski, 1996). Given that modern technologies are complex and characterized by complementarities (Chiesa, 1996; Rosenberg, 1976), a high-tech firm’s success in one innovation requires gaining access to other innovations and technologies developed elsewhere (Ferne, 1998). IMD takes TMCs closer to the centers of innovation located outside their domestic markets, thus promoting greater learning of new technological skills (Tihanyi et al., 2005). TMCs use subsidiaries with world mandates or “specialized contributor” subsidiaries to obtain new technological knowledge from foreign markets.

Technological performance is the accomplishment of firms with regard to the combination of their R&D input (R&D expenditures) and R&D output (patents) (Hagedoorn & Cloozd, 2003). DeCarolis and Deeds (1999) relate a firm’s knowledge measured in terms of stocks and flows—stocks by the number of patents and flows in terms of R&D investments. Various studies have shown a strong correlation between R&D intensity and patents (Ahuja & Katila, 2004; Hagedoorn & Duyters, 2002). Kogut and Zander (1993) stated that entry or expansion into foreign markets alters the global knowledge of that firm. The entry increases the chances of the proliferation of diverse types of technological knowledge and capabilities.

In sum, internationally diversified technology oriented corporations can gain access to many resources and inputs that can spur innovation (Chari et al., 2008; Kotabe, 1990; Tihanyi et al., 2005). As IMD rises, the TMCs are likely to engage in more innovations by spending more on R&D, a process that can generate more patents (Mansfield, 1989; Scherer, 1984). The knowledge gained through IMD can also promote the TMCs’ learning of new skills and the acquisition of insights about best practices in managing and using modern technologies. This process can strengthen a TMC’s overall technological capabilities. These observations suggest the following hypotheses:

**H1:** International diversification (IMD) is statistically significant and positively related to the TMCs’ Technological Innovation and Capabilities.

**H1a:** IMD is positively related to R&D activity.
**H1b:** IMD is positively related to Number of Patents.
**H1c:** IMD is positively related to the Technology Strength.

**Product Diversification (PD) and Technological Innovation & Capabilities**

Some prior empirical research suggests that PD can negatively affect a firm’s innovation, as measured by R&D intensity (Hitt et al., 1997). Several studies have shown that small to moderate amounts of PD can reduce R&D intensity, a factor that would lower a firms’ technological capabilities. Changes in the TMCs’ organizational culture and structure appear to detrimentally underlie the effect of PD on the intensity of R&D spending. The widespread use of financial controls can induce risk aversion and reduce innovation (Hoskisson & Hitt, 1988; Baysinger & Hoskisson, 1989; Hitt et al., 1996). As PD increases, a management’s ability to process information about the TMCs’ diverse products, markets and customers is also challenged, increasing the use of financial controls. As PD increases, the financial controls prevail, R&D investments decline (Hitt et al., 1994), promoting a focus on incremental innovations that do not generate patents.

Given that PD is often achieved through acquisitions that are financed by debt (Hitt, Hoskisson, Ireland & Harrison, 1991), some high-tech firms may reduce their discretionary expenditures such as investments in R&D. Increased debt often limits a manager’s discretion by reducing the slack resources needed for innovation (Hansen & Hill, 1991; Hoskisson & Hitt, 1994; Litchenberg, 1994). Consistent with these arguments, some studies have found a negative relationship between PD and R&D intensity in U.S. (Hoskisson & Hitt 1988; Baysinger & Hoskisson, 1989; Hitt et al., 1997) and Japanese companies (Doi, 1985). As PD rises, some TMCs also adopt M-form organizational structures (Hoskisson & Hitt 1994) that reduce inter-unit communication and the transfer of knowledge (Hamel & Prahalad, 1994). Furthermore, as PD increases, the TMCs might spread themselves too thin and lose sight of the sources of their marketing and technological advantages.

The organizational learning perspective suggests that companies that pursue PD can build strong technological capabilities by spending heavily on R&D, obtaining more patents, and quickly developing new technologies. This continues until a peak is reached by the TMC and then the performance begins to decline. As PD continues, however, inter-unit communications become difficult, time consuming, and costly. Turf wars among the units may ensue, depriving the firm of technological synergies. Coordination and communication problems become so severe that gains in technological capabilities begin to decline. These declines are further exacerbated by a lack of support for other innovation activities as financials dominate strategic controls. Thus, a curvilinear relationship resembling an inverted U-shaped curve is expected between PD and technological capabilities.

It has been demonstrated that European and U.S. executives recognized PD as a strategy to build strong technological capabilities and they also noted the
importance of PD in developing these capabilities (Kerin et al., 1990). In general, multinational enterprises with a high PD can enjoy economies of scale and scope, thereby increasing their returns from their innovations while spreading the risk (Teece, 1981; Teece et al., 1997). TMCs with high PD will have an incentive to maintain strong R&D programs that support their business objectives. Thus, diversified TMCs can benefit from having efficient R&D programs which support their diverse operations while reducing their risks of failure. This can encourage investments in R&D, improve the firm’s ability to build stronger technological capabilities, and generate a higher number of patents (Arzt et al., 2010; Griliches, 1998; Scherer, 1989). A higher PD will be positively associated with the outcomes of TMCs’ innovation process.

Product diversification (PD) also strengthens the TMCs’ technological position. As the TMCs expand their product lines to achieve higher PD, their pool of knowledge expands. Knowledge can be leveraged to build stronger market position. One way to do this is to embed the technology into the TMC’s products, making them difficult for the competition to imitate (Porter, 1985 & 1990). Alternatively, TMCs can use their technology to upgrade their products making them current and easier for customers to use (Day, 1994). These actions allow the TMCs to capture and retain high market share and achieve profitability. PD is an important means for acquiring distributed technological competencies (Argyres, 1996; Chari et al., 2008; Wolf, 1977) that can spur learning and knowledge creation.

Contrary to our conventional and traditional notions of significant effect of PD on technology innovation, some innovations are likely to be incremental in nature. Even when unsure about the full implications of their discoveries, firms may patent them in order to stake their claims to certain technologies, put a roadblock to a rival’s entry, or exercise an option at some point in the future. Firms may also swap patents to gain access to other companies’ innovations (Mowery and Teece, 1993; Mowery et al., 1996), which can strengthen the TMCs’ ability to develop new products, obtain more patents, and strengthen their own technological base.

In sum, a high PD can intensify the high-tech firm’s R&D spending, increases the number of its new patents, and improve its technological capabilities. Indeed, past studies (Link & Long, 1981; McEachern & Romeo, 1978) have reported a positive association between PD and R&D intensity. High R&D intensity yields new products (Galan & Sanchez, 2006) and patents (Griliches, 1984). Other studies (Arzt et al., 2010; Baysinger & Hoskisson, 1989; Chari, 2008; Lunn, 1987; Shin, 2006) have also found a positive association between PD and technology innovation activities including the number of patents. Thus, our discussion suggests the following hypotheses:

H2a: Product diversification (PD) is statistically significant and positively (but curvilinearly) related to the TMCs’ Technological Innovation and Capabilities.

H2b: PD is positively (but curvilinearly) related to the number of patents.

H2c: PD is positively (but curvilinearly) related to technological strength.

The Interactive Effects of IMD and PD on Technological Innovation and Capabilities

International and product diversification may also interact to determine a TMC’s innovations (Hitt et al., 1994, 1997). Though several studies have explored the interaction of international and product diversification on financial performance (Grant et al., 1988; Hall & Lee, 2010; Sambharya, 1995; Tallman & Li, 1996), the effect of this interaction on a TMC’s R&D intensity and patents has received scant attention (Hitt et al., 1997). Using the evolutionary theory and the dynamic capability perspective, it becomes clear that TMCs can use the expertise gained from market and product knowledge to enhance and develop their technical capabilities.

As afore-proposed, international market diversification (IMD) contributes to TMCs innovative capabilities by increasing their exposure of TMCs to technological knowledge bases worldwide by absorbing capacity, investing in lead markets, and learning from local spillovers. Product diversification can also enhance innovation capabilities by taking advantage of inter-temporal and intra-temporal economies of scope by redeploying their resources among businesses over time and share those resources contemporaneously (Helfat & Eisenhardt, 2004). Thus TMCs expand their reach through both types of diversification.

However, PD may depress the predicted positive effect of IMD on the outcomes of TMCs’ innovation efforts. As PD rises, TMCs will use their financial resources to support the operations of their increased product diversification portfolio, hoping to cultivate the technological skills that already exist within their operations. Business operations derived by an increased PD can reduce R&D spending (Hitt et al., 1997). Lower R&D spending can reduce the availability of talented researchers for future innovation which can slow down the development of new technology. Thus, as PD increases, new layers of management are installed (Hoskisson & Hitt, 1995), further slowing down the speed of technology development. These observations are consistent with past studies in which PD will negatively moderate the effect of ID on innovation (Hitt et al., 1994).

Previous research has also shown that the interaction of IMD and PD leads to an increase in the variance explained in firm performance (Tallman & Li, 1996). Those TMCs that achieve the optimal combination of IMD and PD are usually successful (Hall & Lee, 2010; Sambharya, 1995). Similarly, TMCs that can handle the complexities of both IMD and PD simultaneously will get the maximum benefits from their innovation activities. TMCs also can gain from spillovers from PD by increasing innovations. Given the globalization of R&D activities, the interaction of international and product diversification should improve both the TMCs’ innovation base in terms of R&D spending and patents. These observations lead to the following hypotheses:

H3: The interaction of IMD and PD is statistically significant and positively related to...
the TMCs’ Technological Innovation and Capabilities

H3a: The interaction of IMD and PD is positively related to R&D intensity.
H3b: The interaction of IMD and PD is positively related to number of patents.
H3c: The interaction of IMD and PD is positively related to technology strength.

Empirical Design and Methodology

Selected Samples and Data Collection
The sample of this study was initially taken from The Directory of Multinationals which profiled 458 of the World’s largest industrial corporations, with sales of over $1 billion (U.S. dollars) with significant international operations. However, initially finance related firms (SIC 6000-6999) and service oriented firms, excluding tech service related firms (SIC 7370-7376), were eliminated to maximize the generalizability and reliability of the study. The initial sample was additionally confirmed through the Patent Scoreboard by the U.S. Patent and Trademark Office and Patent Scorecards by MIT Technology Review. A total of 197 leading firms in the U.S.A., Japan and European countries (EEC) were selected for the purposes of the present study (see Table 1). All other data for the variables including R&D expenditures were taken from Compact-D Word Scope and Research Insights for the period 2000 through 2004. Because the sample is a quasi panel dataset and had missing values for some firms and years, we used the five-year aggregated averages of all the variables tested in this study for the period through 2000 through 2004. A five-year period was chosen in an attempt to avoid any issues that may be associated with a one-year fluctuation. Aggregated averages were used to help minimize the effects of any outliers or idiosyncratic variations; thereby, providing a more accurate assessment of the effects of the variables being studied (Hall & Lee, 2010).

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Insert Table 1 about here
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Description and Measurement of Variables

Technology (Dependent) Variables. The dependent variables were measured as follows:

R&D Intensity was measured as the firm’s allocations to this activity (i.e., R&D expenditures) as a percent of its annual sales and it was used as one of proxies for innovation (Hitt et al., 1997). The barometer to gauge the firm’s technological and innovative capability is the extent to which the firm concentrates and invests in research and development. The R&D intensity ratio is commonly and widely used in studies of innovation (Baysinger & Hoskisson, 1989; Hall & Lee, 2010; Hitt et al., 1997).

Number of Patents were measured by the number of patents granted to firms by the U.S. Patent & Trademark Office. This number excluded design and other special case patents. Though incomplete, the number of patents obtained in the U.S. is a valid proxy for a firm’s overall patenting activities (e.g., Patel & Pavitt, 1991, 1998). The attractiveness of the U.S. market encourages the patent process for inventions that are of significant commercial importance (Zander, 1997). Narin and his colleagues (1987) also provide extensive evidence on the validity of this measure.

Technological strengths (as one of the aggregate ratings to indicate the overall quality of a company’s patent portfolio: MIT Technology Review) were measured by the firm’s number of patents awarded to the company times the Current-Impact Index (CII). The current impact index (CII) measures how significant a patent is and how often a company’s patents from the previous five years are cited in the current year’s batch (e.g., A value of 1 represents the average citation frequency, so for an example, a value of 1.2 indicates this company’s patents are cited 20% more than average). These citations indicate the technological, scientific or marketing importance of a given patent. Thus, this measure adjusts for some of the weaknesses associated with using total patent counts. Data for the later time period 2000-2004 was bought from the CHI research firm. Patent citations have been widely used in the innovation and R&D literature (Ahuja & Katila, 2004; Hagedoorn & Cloddt, 2003; Jaffe & Lerner, 2001; Markmann et al., 2004). Narin, Noma and Perry (1987) also provided extensive evidence on the validity of these measures.

Corporate Diversification Variables. Both product and market diversification were computed using an entropy measure with data obtained from the Directory of Multinational and Compustat (Chari et al., 2008; Palepu, 1985). The entropy measure is widely used in corporate strategy literature and it also provides more comparative application to corporate diversification (Jacquemin & Berry, 1979). Specifically, they were measured as follows:

Product Diversification (PD) was measured using an entropy measure (Jacquemin & Berry, 1979; Hall & Lee, 2008; Palepu, 1985). This measure, which has been used in prior research (Chari et al., 2008; Hitt et al., 1997), was calculated as follows: PD=∑(1/Pi). Pi was the sales reported by a given business segment i. Ln (1/Pi) was the natural logarithm of a given segment’s sales and was the weight given to that segment. Prior research found that this measure had good construct validity compared to other measures (Hitt et al., 1996).

Market Diversification (IMD) was also measured using an entropy index (Hall & Lee, 2008; Hirsch & Lev, 1971; Miller & Pras, 1980; Hitt et al., 1997) and was calculated using the formula: ID=∑[P x ln (1/P)]. Pi was the sales reported by a given market region i. Ln (1/Pi) was the natural logarithm of that region’s sales and was the weight assigned for that region.

Strategic Control Variables including Performance Measures. Several other strategic factors in business and operations including two performance measures with respect to accounting-based and market-based performance measures were also employed as controls in the relationship between technological capabilities and corporate diversification. These control variables are measured as follows:

Firm size was measured by the natural log of the
was entered in the first regression model to explore the impact of technology on different size of firms across countries. All other control variables were added to the model 2 to examine the focus of technology factors on traditional business and operations strategies. In order to provide more exploratory implication to linkages between implicit technological capabilities and diversification strategies, two major corporate diversification strategies were, individually and jointly, used in the models 3 and 4. By eliminating the effects of the control variables in the initial steps, it was possible to more accurately assess the true impact of technology efforts on corporate diversification and diverse firm performance. Empirical models are specified below:

Technology Efforts (R&D Intensity, No. of Patents, Technology Strength) = 
Performance (OPROA, Tobin’s Q)

Model 2: country dummy, firm size, performance, business & operations
strategy factors (leverage ratio, operating cost efficiency, capital intensity, inventory turnover, average collection period)

Model 3: country dummy, firm size, performance, business & operations
strategy factor, market diversification, and product Diversification

Model 4: country dummy, firm size, performance, business & operations
strategy factor, market diversification, product Diversification, and Joint factor of market-and product-diversification.

Empirical Analysis and Discussion

Descriptive Statistics and Correlation Analysis
The means and standard deviations for technology variables, including diversification strategy, performance measures and all other control variables across countries are displayed in Table 2. Japanese firms show a higher mean than that of other countries for most technology indicators with respect to R&D intensity, number of patents, and technology strength. This indicates that Japanese firms are superior to those of other countries. Therefore, firms in Japan are more likely to reinforce the technology capabilities with a higher emphasis on R&D expenditures to expand and maintain competitive edge in the global market. The technological diversification strategy through R&D efforts in Japan has been traditionally intensified by the governmental R&D policies in which competing firms share researchers and costs and the government provides funds and tax benefits (Komada, 1986). With respect to corporate diversification strategy, Japanese firms are more likely to be less diversified in product while they are more diversified in the market. This finding tends to confirm that geographic expansions appeared to be a more effective strategy for improving the performance in Japanese firms (Delios & Beamish, 1999). The firms in the European countries show more diversified strategies than those in the other two countries. But the
U.S. firms seem to outperform in both accounting- and market-based performance, during the time period of the study compared to those in other countries. In addition, the U.S. firms appear to be more diversified in product than those of other countries.

Table 3 presents the inter-correlations for all the variables used in the study. To avoid multicollinearity problems that are most likely to skew the correct interpretation of multiple regression models with interaction effects, we centered the diversification strategy and also separated possible potential factors (i.e., squared value of product diversification and interaction factor of product-and market-diversification)(Aiken & West, 1991; Hair et al., 2010). Then, we found that the problem of multicollinearity does not appear to exist since the Variance Inflation Factors (VIFs) were well below the threshold value of 10, i.e., none of our VIFs were above 3.19 (Hair et al., 2010).

As presented in Table 3, most technology factors are positively and significantly correlated with corporate strategy factors at 0.01 level (except for product diversification; p<0.05). They are also positively correlated with performance measures, but significantly correlated with Tobin’s Q only (p <0.01). These results also support that technological competence through R&D intensity can be significantly related to IMD (Dedrick et al., 2003; Hitt et al., 1997; Tihanyi et al., 2009). That is, technological strength can be used to achieve more efficient coordination by reducing the costs of coordinating business resources across multiple products and markets (Shin, 2006). With respect to the impact of corporate strategies on firm performance, only market diversification appears to be positively and significantly correlated with most dimensions of performance measures (p <0.01) across countries being studied. Although diversified firms can be more profitable and maintain competitive edge in the global market, product diversification may not contribute to the firm’s performance. Rather, the effect of diversification on financial performance and firm value is likely to be more significant when their strategic scope and direction is oriented by a greater level of related diversification (Chari et al., 2008; Shin, 2006). As expected, firm size is uniformly significant (p <0.01) and positively correlated with a majority of technology factors and diversification strategies regardless of different dimensions and scopes.

In summary, the strategic impact of corporate diversification strategies on products and markets, performance, and other business and operations strategic factor does not seem to be uniformly correlated among variables utilized in this study. However, both market and product diversification are positively and significantly correlated with a majority of technology factors with respect to R&D intensity, number of patents, and technology strength. All technology factors and diversification are positively and significantly correlated with market-based performance (e.g., Tobin’s Q), while only technology strength is significant in accounting-based performance (e.g., OPROA). The firm size is uniformly and positively correlated with a majority of technology factors and diversification strategies in generating a higher performance. Other variables, such as capital intensity, leverage, operating cost efficiency, inventory turnover, and average collection period do not show correlations with technology capability.

Results of Hierarchical Regression Analysis. Using hierarchical multiple regression analysis, the empirical models shown were estimated separately with three different technology factors. Furthermore, this analysis was used to examine the significant effect of corporate diversification strategy in product and market. Other selected strategic factors on various dimensions of technological capabilities were also explored. As presented in Tables 4, 5 & 6, the hierarchical regression analysis was used to empirically explore the nature of the relative significance of corporate diversification on a firm’s various aspects of technological competences, after controlling all moderating variables in a separate and simultaneous steps of the model. All regression models were highly significant (p < .001), indicating that the multiple regression models were useful in exploring the major determinants of technological competence across different countries. The results show that the study’s statistical control variables together contributed a significant portion of the variation in the R² (from 0.2543 to 0.4371). Therefore, the results provide more confidence in arguing that even when other strategic factors are held constant, corporate diversification and two dimensions of performance measures are likely to be conducive to facilitating the firm’s technological capabilities in the leading high-tech firms across countries. As expected, the effect of the number of patents and technology strength of measuring the overall quality of a company’s patent portfolio appeared to be confined to R&D intensity. More importantly, market-based performance is more likely to significantly affect technological competence and, to a greater extent, market diversification. As previously examined, firm size was significantly associated with the TMCs’ technological capabilities in the global market.

The Effect of Diversification Strategy on R&D Intensity. Table 4 presents the results for the effects of diversification on R&D intensity (H1a, H2a, H3a). Results for models 2 and 3 indicate that both PD and IMD significantly influence R&D intensity at least at the 0.01 level, thereby supporting H1a, H2a. Although the effects of IMD and PD are different in their signs, diversification significantly influences R&D investment (Baysinger & Hoskisson, 1989; Galan & Sanchez, 2006) in leading TMCs across countries. But the findings of this study seem to be in contrast to other studies (Doi, 1980; Lopez-Sanchez et al., 2006) demonstrating that there is no evidence of relationship between R&D and diversification. Next, PD has an inverted relationship with R&D intensity (H1a, H2a, H3a). The interaction of IMD and PD is also significant at 0.05level. Firms are more likely to diversify both product and market jointly, where their technological resources, through R&D investment,
have a broader application (Silverman, 1999). The results also appear to support the notion that technological capabilities through R&D intensity is facilitated by market diversification. Both IMD and PD are significantly related to R&D intensity linearly and in the form of an inverted U shape, as predicted in H1a and H1b, respectively. Although the result of our study for the effect of the interaction of IMD and PD on R&D intensity is inconsistent with previous studies (Hitt, et al., 1994 & 1997), the interactive effects of ID and PD are significant and add to the total variance explained by less than five percent (p<0.05).

The Effect of Diversification Strategy on Number of Patents. Table 5 presents the results of regression analyses for the number of patents. An additional control variable (past R&D spending) was added to the other control variables used in the case of R&D intensity. The results show a strong support for both hypotheses H1b, H2b, and H3b. About 3.8 percent increases in the amount of variance explained as independent variables are added to models 3 and 4, respectively. The results from patenting (H1b, H2b, and H3b) are also consistent with the previous finding that IMD provides major and significant opportunities for innovation by exposing firms to different systems of innovation (Kogut, 1990) and centers of excellence around the world (Porter, 1998). IMD also enhances learning from the firm’s global partners and customers (Hitt et al., 1994; Hitt et al., 1997). Of course, given that IMD is conducive to higher R&D spending, it can further increase the firm’s patents. Consequently, internationally diversified firms are likely to innovate with greater frequency than less diversified firms, a process that generates more patents.

Contrary to our expectations, the effect of product diversification on the firm’s patenting process does not appear to be clear (Scherer & Ross, 1992). As reported in Table 5, there is an inverted U-shaped relationship between PD and the number of patents. This result supports H2b (Hitt et al., 1994). They also highlight the concern that as PD continues to increase until a threshold is reached and then the number of patents declines. The reason may be that the information about the firm’s innovation activities is communicated to the top management, or it becomes increasingly difficult for executives to focus on turning the learning gained from PD into patents. Although IMD, PD and the interaction of IMD and PD are significant at 0.05 level, PD² is not statistically significant. Thus, hypothesis H2b was not supported. Specifically, the relationship between PD and the number of patents is linearly associated as predicted.

The Effect of Diversification Strategy on Technology Strengths. Table 6 presents the regression results for technological strengths which indicate overall quality of patents. Models 3 and 4 indicate that our proposed hypotheses (H1c and H3c) were partially supported, while hypothesis 2c (for PD) was not supported. Though IMD is significantly related to the firm’s future technological intensity, the relationship between IMD and technological strength is linear but not an inverted U-shape as the hypothesis predicted. Furthermore, though the interaction of IMD and PD is highly significant (p<0.001), it does not significantly add to the variance explained. Results of regressing differences in technological strength on the differences in the control variables, IMD, PD, PD², and the interaction of PD and IMD are shown in models 3 and 4. These results indicate that hypothesis 1c and 3c are supported. The interaction of IMD and PD is significant; it also improves the variance explained about three percent, from 0.3229 to 0.4058 (p<0.001). Overall, the proposed hypothesis (H1c) for variations in technological strengths have a significant effect on IMD (p<0.001) but not on PD. In all three cases, the interactions of IMD*PD are significant at the 0.001 level; it also improves the variance explained by a modest two to four percent (p<0.001).

Effects of Performance and other Strategic Factors on Technological Capabilities. As explored through hierarchical regression analysis, the firm performance and other strategic business and operations factors also significantly affect the firm’s technological capabilities. First, firm size is uniformly and significantly associated with most technological innovation. In fact, technology innovation is more productive in large firms as a result of complementarities between R&D efforts and other functional activities, such as marketing and operations (Cohen, 1995). Also financial advantages due to cost spreading are shown in Cohen (1990) and Cohen & Klepper (1996). In a recent study, Artz et al. (2010) also empirically demonstrated that the firm size was significantly and positively related to both patents and R&D spending. Second, a majority of past studies support the significant effect of a firm’s performance on technology development as well as the significance of the use of technology to improve performance (Artz et al., 2010; Chari et al., 2008; Lopez-Sanchez et al., 2006). Consistent with earlier studies, our study also appears to prove the competitive advantages of firm performance to increase technological capabilities and strengths. But the performance impact of technology strength is significant in a market-based performance, particularly with respect to Tobin’s Q only (Miller, 2006). As expected, a firm’s R&D intensity is a good predictor of its patenting disposition and overall quality of patenting at least at the 0.01 level. It is supported that TMCs are using patents as strategic tools to take advantages over their competitors in a rapidly changing market. One possible justification of this phenomenon is that R&D intensity and quantity of patents can be used as a safeguard to create incentives for technological competencies and a defensive maneuver to protect strategic position in conjunction with other firm specific resources (Artz et al., 2010).

Country Differences on Technological Capabilities. The effect of country differences on TMCs’ technological capabilities are not uniform and are mixed in terms of various aspects of technology strength. Marginal values of all technological innovations and capabilities in the U.S. firms are most likely to be higher than that of the European countries (p<0.05). Such significant differences in technological strengths between Japanese firms and European firms appear to exist in terms of R&D intensity only. Thus, the effect of selected strategic variables including corporate diversification on the TMCs’ technological competences is not significantly different between Japan and European countries (EC).
Major Findings and Conclusions

Technological innovations and capabilities are the core of the firm’s ability to innovate and compete in today’s global markets. Research suggests that the product and international diversification strategies (PD and IMD) in TMCs can profoundly affect their future technological capabilities, particularly in high-tech industries. Most prior studies, however, have been limited by their use of U.S. databases and/or an industry segment. Examining only R&D spending as a surrogate for technological capabilities and employing short time spans in investigating the link between the TMCs’ diversification and their technological capabilities are scant. The present study highlights the link between the globalization of technology and globalization of firms. One of the most crucial sources of competitive advantage for high-tech firms is their strong technological capabilities that determine their speed, responsiveness to customers’ needs and demands for innovation. This study joins a growing body of empirical research that shows product and international diversification of TMCs can significantly influence their future technological capabilities, albeit, differently.

The first noteworthy finding of our study suggested that IMD is positively associated with the firm’s future technological capabilities. The findings of this study are consistent with the theory (Kobrin, 1991; Hitt et al., 1994) and prior empirical findings (Hitt et al., 1997; Kotabe, 1990). It appears that IMD gives high-tech firms the incentive to invest heavily in R&D activities to build strong technological capabilities to serve diverse needs of different foreign markets. The results for the positive and significant effects of IMD on the TMCs’ technological capabilities also suggest that diversified firms have the resources needed to maintain strong R&D activities which allow them to develop the technological capabilities required to develop new products and goods as well as customize their offerings for different markets. Our findings support the past assertions that competition in TMCs is knowledge-based, and R&D activities are among the most important sources for creating this knowledge (Leonard-Barton, 1995). In summary, the results show that IMD is associated with greater R&D investments, more patent development, and stronger technological capabilities. These results are consistent with the recent discussion in the literature of the powerful role of a firm’s network (Ghoshal & Nohria, 1989) in developing technological capabilities (Cantwell, 1995; Nobel & Birkinshaw, 1998; Zander, 1997).

As expected, the results for product diversification (PD) are not as uniform or as strong as those for market diversification (IMD). Our analyses reveal an inverted U-shaped relationship between the level of PD in TMCs and future R&D spending. This finding indicates that as TMCs become more diversified, their R&D investments increase until a threshold is reached, and then R&D investments begin to decline. The initial increases are consistent with the predictions of the learning perspective (Huber 1991), while the declines appear to support the strategic control perspective (Hitt et al., 1997; Hoskisson & Hitt, 1996). Thus, the findings of our study reveal an inverted U-shaped relationship between increases in PD and increases in future R&D investments intensity. Overall, a higher PD is related to stronger technological skills. The relationships between PD and changes in PD as well as technological strengths are also positive and linear, contrary to speculations in the literature (Hitt et al., 1994). Even though the results did not fully support the predicted relationship, they still help to clarify the effect of the TMCs’ global PD activities. The failure to capitalize on technological synergies in developing new technologies is a serious problem in TMCs that sometimes fail to integrate the technological learning that occurs within their diverse operations. It suggests that as PD increases through significant amount of patenting, information processing for competitive edge becomes difficult and technological accumulation in technology oriented firms starts to decline.

Finally, one of the major findings in this study also indicates that IMD and PD have positive effects on the firm’s future technological capabilities. This is evidenced by consistently positive and significant relationships between the ID*PD interaction terms and future R&D intensity, patents, and technology strengths. Indeed, most interactions are highly significant and positive, though the magnitude of the effect varies depending on the particular measures used for the dependent variables. As noted earlier, IMD gives product-diversified high-tech firms the incentive and resources to strongly support future R&D efforts. IMD also gives firms an opportunity to gain new knowledge that improves their ability to innovate to increase their patent potential and build stronger technological capabilities. The task of top management in high-tech firms is to balance and optimize the degree to which they are diversified (i.e., in both IMD and PD) and to gain the maximum benefits both in terms of technological capabilities and financial performance.

Limitations and Implications of the Study

The above results should be interpreted with the study’s limitations in mind. Although this study attempts to explore the strategic impact of corporate diversification on the firm’s technological capabilities and competencies across countries, the results may have some limitations in regard to different industry and country characteristics. Furthermore, this study did not capture the dynamic interplay between a firm’s diversification activities and technological capabilities. Another limitation of the study is its reliance on data from three major world clusters in examining the diversification-technological capability relationship. While these three clusters are the most important worldwide centers for innovations as noted earlier, other centers of technological innovation also exist (Porter, 1998). Finally, because the TMCs examined in this research are among the most powerful in the high-tech industries and markets, the results may not apply to smaller firms, regardless of their country of origin and industry characteristics.

Although there are limited relevant literatures to support and/or justify the foundation and findings of this study, this study explores the impact of corporate diversification and performance on a firm’s technological capabilities and should warrant more attention in the future. One of the key findings of this study is that international market diversification can significantly

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influence a firm’s future technological capabilities, whether measured by R&D intensity, or overall patent application as a proxy measure of technological strengths. The results also suggest several avenues for future research in this area. Considering some limitations described above, more studies would help to further explore the relationships between diversification and technology that might exist across different industries and countries. The strategic motives to expand market may differ by industries (Hall & Lee, 2010; Hennart & Parks, 1993). Furthermore, the effects of market diversification on technological capabilities are expected to be significantly different with respect to the different scope and patterns of industry such as growing vs. declining and high-tech vs. low-tech industries. Researchers would benefit from examining the effect of industry variables on market diversification and technology relationships across countries. The understanding of the linkage between corporate diversification and technological capabilities will not only engage us with efficient and effective strategic planning but it will also help a firm to gain a competitive advantage. As a matter of fact, this study has opened the door for additional research efforts to generalize the relationship between technology and diversification in the leading high-tech industries worldwide.
EMPIRICAL EVIDENCE OF CAUSALITY BETWEEN INFORMATION COMMUNICATIONS TECHNOLOGY AND ECONOMIC GROWTH IN CHINA, JAPAN AND SOUTH KOREA

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ABSTRACT

This study examines the causal relationship between information and communications technology (ICT) development and economic growth in three of the Northeast Asian countries: China, Japan and South Korea. The Granger causality test is performed following the cointegration approach to reveal the direction of causality between ICT development and economic growth. Test results indicate two things: 1) there is a long-run equilibrium relationship that runs from ICT development to economic growth in South Korea; and 2) a one-way directional causality of growth-led ICT development for China is evidenced. A discussion follows based on the empirical findings.

Keywords: Information and communications technology, infrastructure, economic growth, ICT-led growth hypothesis, Granger causality.

INTRODUCTION

Over the past decade, the development of information and communications technology (ICT) and the investment in the ICT sector has been increasing rapidly in many countries. The fast growth of ICT infrastructure can be explained by a number of factors, such as advancements in ICT related technologies and services and market demand. In particular, over the past decade, many countries have seen explosive growth in mobile communications. Mobile communications are experiencing accelerated growth rates in both developing countries and developed countries in recent years. The diffusion of mobile ICT services has not only facilitated market competition but also attracted a lot of domestic and foreign investment into the ICT sector. During the past decade, world economic output has also been growing at a fast rate, and in particular, in Northeast Asian countries such as China and South Korea. It has been widely recognized that the advancement of ICT is one of the driving forces of globalization and the rapid growth of the world new economy.

Economic growth is the increasing ability of a nation to produce more goods and services. The use of ICT can enable the production of goods in a short amount of time and services are also provided more efficiently and rapidly. Growth can occur in many different ways, for example, the increased use of land, labor, capital and business resources and increased productivity of existing resources use by using ICT. ICT investment can also increase economic growth in many ways. ICT networks provide the framework for the delivery of different services, improves communications between firms, spreads to other industries and contributes to their profits affecting overall economic growth. The increased economic importance of ICT raises new questions for governments regarding the best policy frameworks to adopt for encouraging both ICT investment and ICT-led growth. The rapid diffusion of ICT in the past decades also introduces new policy issues for consideration, such as the effect of ICT on the distribution of economic activity and the influence of ICT on productions.

Does the development of ICT infrastructure lead the increase of economic growth? Or does the increase of economic growth lead the development of ICT infrastructure? It is a vital question to explicitly disentangle the effect of ICT development and investment on economic growth. For this reason, the causal relationship between ICT development and economic growth has long been a subject of interest for empirical investigation. To date, a large number of studies have focused on explaining the economic impact of ICT development on economic growth and the issue has ranked among the active research fields since the issue has received considerable regulatory and public policy attention in many countries. ICT-led economic growth tends to occur when ICT development is one of the factors that affect economic growth, its contribution to the overall economy has varied between countries at different stages of development. To date, results of the causal relationship between ICT development and economic growth have been mixed. As a matter of fact, research results for the relationship between ICT development and economic growth are inconclusive. It is therefore questionable to generalize from the study of one country to that of the world’s largest emerging economies such as China.

This study thus examines a causal relationship between ICT development and economic growth in the three Northeast Asian countries: China, Japan and South Korea. This study aims to answer the following two questions: First, is there a long-run equilibrium relationship between ICT development and economic growth? Second, what is the direction of causality between the two variables in the short-run? This study aims to contribute to the literature testing the ICT-led economic growth hypothesis. This study employs cointegration tests to investigate a long-run equilibrium and Granger causality tests to investigate directional causality in the short-run between ICT development and economic growth.

LITERATURE REVIEW

Many studies have reported that there exists a positive correlation between ICT development and economic growth in the country level. For example, Thompson and Garbacz [1] reported that the development of ICT has a significant positive impact on productivity growth to the world as a whole, but particularly so for developing countries, by improving the efficiency of how these and other resources are used. Kraemer and Dedrick [2] and Dewan and Kraemer [3] reported that there exists a positive correlation between ICT development and economic growth in the Asia-Pacific region. Many studies

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have also reported that ICT investments contribute positively to economic growth in the country level, for example, in many OECD countries [4] [5] [6].

Many studies have reported that ICT development is one of the main drivers of better economic growth and sustainable economic growth [7] [8] and higher productivity [9] [10] in many developing countries. They reported that ICT development plays an important role in the economic growth of developing countries. Lee, Gholami and Tong [11] reported that ICT development contributes to economic growth in many developed countries and newly industrialized countries, but not in developing countries. For example, many empirical studies supported that there exists a one-way directional causal relationship from ICT development to economic growth in the United States [12] [13], in a group of OECD countries [14] [15] [16] [17]. In addition, many studies argued that there is not much evidence to indicate that ICT development leads to economic growth in developing countries [18], in China [19], in Taiwan [20]. On the contrary, Gordon [21] reported that ICT sector benefits from economic growth. Shiu and Lam [22] reported that there exists a one-way directional causal relationship that runs from economic growth to ICT development in China. The result is consistent with some of the previous studies which have found a limited impact of ICT development on economic growth, in particular, for developing countries [23] [24] [25].

On the other hand, Lam and Shiu [26] reported that there is a bidirectional relationship between ICT development and economic growth for European high-income countries. Many studies reported that there exists a bidirectional causal relationship between ICT development and economic growth in South Korea [27]) and in 15 industrialized countries [28]. They found that although causality is generally in both directions, ICT development more strongly precedes the nations’ economic growth. Chakraborty and Nandi [29] reported a bidirectional causal relationship, in both the short-run and long-run, between ICT development and economic growth in twelve developing countries in Asia. Munnell [30] and Gramlich [31] also reported a bidirectional relationship between ICT development and economic growth. They found that the effect of ICT development on economic growth is positive and the direction of causation runs from economic growth to ICT development as well.

Since the results of previous studies of the causal relationship between ICT development and economic growth have been mixed, this study suggests that the causal relationship between ICT development and economic growth may not be independent of the level of economic growth and ICT development of countries. Therefore generalizing from the study of one country to other countries should be a significant contribution to the body of literature in this domain. The empirical application of this paper uses the three largest Northeast Asian countries including China, Japan and South Korea, based on data availability and compatibility to test for the validity of the theoretical findings. Accordingly, the following hypotheses are considered:

**Hypothesis 1:** There is a long-run equilibrium relationship between ICT development and economic growth.

**Hypothesis 2:** ICT development leads to economic growth.

**Hypothesis 3:** Economic growth leads to ICT development.

### RESEARCH METHODOLOGY

#### Data

Though various indicators of world ICT development are reported periodically by International Telecommunication Union, the periodic instability among the most commonly used measurements deter the need to rely on a single superior measure. Moreover, as good as the indicators may appear, the paucity of data in the ICT development in many developing countries poses a serious problem for the adoption of many of the indicators due to limited data availability and comparability. In this reason, different researchers have employed different indicators in their measurement of ICT development. Therefore, the accuracy of a proxy has not been subject to careful statistical scrutiny. Despite these facts, mobile and fixed-line telephone subscribers (per 100 people), were used as a proxy of ICT development for the countries in this study because they are universally measured and a consistent index collected by the international agencies and also, their longitudinal data availability corresponds well with that of real Gross Domestic Product (GDP).

The data on real GDP, real exchange rates relative to the US dollar, are used as a proxy of economic growth for the countries in this study. The information of GDP and mobile and fixed-line telephone subscribers (per 100 people) has been obtained from the world development indicators of the World Bank (http://data.worldbank.org/) and has been reported on an annual basis. The yearly time-series of the information were available from 1960 to 2009. To match the time period with ICT development, the GDP was chosen yearly from 1975 to 2009 (35 observations) for this study. Additionally, the two time-series are seasonally unadjusted and, therefore, transformed into a natural log form to minimize any possible distortions of dynamic properties of the data and thus to remove a heteroscedasticity problem from the model initially.

#### Unit root test

Most of economic time-series data are likely to be non-stationary. If a time-series is found to be non-stationary, a filtering mechanism such as the first difference of the variable can be employed to induce stationarity for univariate model estimation. Augmented Dickey–Fuller [32] and Phillips–Perron [33] tests are carried to test the null hypothesis of a unit root in the level and the first difference of the two variables. As Enders [34] indicated, the Augmented Dickey–Fuller (ADF) test assumes the errors to be independent and to have constant variance, while the Phillips–Perron (PP) test allows for fairly mild assumptions about the distribution of errors.

Results of both ADF and PP tests for stationarity are reported in Table 1. The null hypothesis of a unit root cannot be rejected in the level of the variables, but all null hypothesis of a unit root is rejected in the first difference of the variables. The results in Table 1 unanimously confirm that all variables are integrated of order one \( I(1) \). The optimal lag in the ADF test is automatically selected based on the Schwarz Info Criterion (SIC) and the bandwidth for the PP test is selected based on the Newey-West estimator [35] using the Bartlett kernel function, and the numeric values are reported in Table 1.
Cointegration test

According to Granger [37], cointegration means that the two non-stationary variables are integrated in the same order with the stationary of residuals. If the two variables are cointegrated, there exists a force that converges into a long-run equilibrium. In other words, if ICT development and economic growth are cointegrated, there is a force of equilibrium that keeps ICT development and economic growth together in the long-run. There are two test methods to identify the presence of a cointegrating relationship between two variables: (a) the Engle-Granger two-stage single equation method [38] and (b) the Johansen-Juselius cointegration test [39]. The Johansen method has two separate tests, the trace test and the maximum eigenvalue test. The Engle-Granger method obtains only one single cointegration relationship whereas it is possible to obtain more than one cointegration relationship with the Johansen method. Given this, the Engle-Granger method is Ordinary Least Squares (OLS) based test and the Johansen method is a maximum likelihood based test that requires a large sample.

For the Engle-Granger two-stage single-equation method in this study, the Augmented Dickey-Fuller (ADF) test equation includes an intercept but no time trend. The test equations were tested by the method of least squares. The Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) test equations include an intercept but no time trend. For both the ADF and PP t-statistics, the probability value for rejection of the null hypothesis of a unit root are employed at the 0.01 level (***, p-value < 0.01), the 0.05 level (**, p-value < 0.05) and the 0.1 level (*, p-value < 0.1) based on MacKinnon [36] one-sided p-values.

The results of the Johansen cointegration test in Table 2 show that the trace statistics and the maximum eigenvalue statistics are smaller than the critical values for China and Japan, except South Korea; therefore, the null hypothesis of no cointegration cannot be rejected at the 5% significance level for the China and Japan cases.

Table 2. Results of the Johansen cointegration test

<table>
<thead>
<tr>
<th>Country</th>
<th>ADF t-statistic (lag length)</th>
<th>PP t-statistic (bandwidth)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ΔlnGDP</td>
<td>ΔlnICT</td>
</tr>
<tr>
<td>China</td>
<td>-4.810***(0)</td>
<td>-3.246** (0)</td>
</tr>
<tr>
<td>Japan</td>
<td>-3.891***(0)</td>
<td>-3.549** (2)</td>
</tr>
<tr>
<td>South Korea</td>
<td>-4.213***(0)</td>
<td>-5.152***(0)</td>
</tr>
</tbody>
</table>

Note: In denotes the natural logarithm of the variable under consideration. Δ denotes the first difference of the variable under consideration. The test equations were tested by the method of least squares. The Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) test equations include an intercept but no time trend. For both the ADF and PP t-statistics, the probability value for rejection of the null hypothesis of a unit root are employed at the 0.01 level (***, p-value < 0.01), the 0.05 level (**, p-value < 0.05) and the 0.1 level (*, p-value < 0.1) based on MacKinnon [36] one-sided p-values.

The results indicate that there is no cointegration relationship between the two variables at the 0.05 level, except the South Korea case, which the trace statistic and the maximum eigenvalue statistic are greater than the critical values, the null hypothesis of no cointegration can be rejected at the 0.05 level. For the South Korea case, the results indicate the existence of one cointegrating equation between ICT development and economic growth in the country.

Therefore, this study concludes that Hypothesis 1 “There is a long-run equilibrium relationship between ICT development and economic growth” is not supported. In other words, there exists no long-run equilibrium between the two variables for the China and Japan cases. In this case the Granger causality test method by an unrestricted VAR model is the best option for testing directional causality of short-run dynamics.

Granger causality test

Engle and Granger [38] note that if two time-series variables are not cointegrated there may be unidirectional or bidirectional Granger causality in the short-run. Short-run causality is determined by test on the joint significance of the lagged explanatory variables, using an F-test or Wald test. The traditional practice in testing the direction of causation

Note: The test equations were tested by the method of least squares. For the Johansen cointegration test, the assumptions of cointegration test allow for leaner deterministic trend in data include an intercept but no time trend and test VAR. For the both trace and maximum eigenvalue test statistics, the probability value for rejection of the null hypothesis of no cointegration is employed at the 0.05 level (***, p-value < 0.01; **, p-value < 0.05; *, p-value < 0.1) based on the MacKinnon-Haug-Michelis [43] p-values.
between two variables has been to use the standard Granger causality test (i.e. pairwise Granger causality tests for bivariate time-series). As an alternative, the short-run Granger causality can be tested by the Wald test. Under the Wald test, the maximum likelihood estimate of the parameters of interest is compared with the proposed value, with the assumption that the difference between the two will be approximately normal. Typically the square of the difference is compared to a chi-squared distribution. The Block Exogeneity Wald test in the V AR system provides chi-squared statistics of coefficients on the lagged endogenous variables, which are used to interpret the statistical significance of coefficients of the regressors. In this way, Wald test statistics can be used to find out the Granger causal effect on the dependent variable. In the V AR system, Granger causality is done to glimpse the short-run causality running from independent variables to a dependent variable, using asymptotic t-statistics that follow chi-squared distribution instead of F distribution. The hypothesis in this test is that the lagged endogenous variable does not Granger cause the dependent variable. For China and Japan, to answer the question regarding the direction of causation in the short-run, the Granger causality tests by unrestricted V AR models are performed.

Engle and Granger [38] and Granger [37] note that if two variables are cointegrated there always exists a corresponding error correction representation in which the short-run dynamics of the variables in the system are influenced by the deviation from equilibrium. For the South Korea case, the existence of a long-run equilibrium relationship between ICT development and economic growth implies that the two variables are causally related, at least in one direction. The V ECM implies that changes in one variable are a function of the level of disequilibrium in the cointegrating relationship, as well as changes in the other explanatory variable. The V ECM is a technique that facilitates to capture both the dynamic and interdependent relationships of the said variables and is a special type of restricted V AR to correct a disequilibrium that may shock the whole system.

The long-run causality is implied through the significance of the t-statistics of the lagged error correction terms. In this case, it estimates the asymptotic variance of the estimator, and then the t-statistics will have asymptotically the standard normal distribution. Therefore, asymptotic t-statistics in this test can be interpreted in the same way as t-statistics, which are used to interpret the statistical significance of coefficients of the lagged error correction terms, which contain the long-run information because it is derived from the long-run cointegrating relationship. The short-run Granger causality can be tested by the Wald test. The Block Exogeneity Wald test in the V ECM system provides chi-squared statistics of coefficient on the lagged endogenous variables, which are used to interpret the statistical significance of coefficients of the regressors. In this way, Wald test statistics can be used to find the Granger causal effect on the dependent variable. The hypothesis in this test is that the lagged endogenous variable does not Granger cause the dependent variable.

Table 3. Results of Granger causality tests (Block Exogeneity Wald tests)

<table>
<thead>
<tr>
<th>Country</th>
<th>Method, “X”</th>
<th>ΔlnGDP (H2)</th>
<th>ECT</th>
<th>ΔlnICT (H2)</th>
<th>ΔlnGDP (H3)</th>
<th>ECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>VAR</td>
<td>1.699</td>
<td>n.a</td>
<td>6.483**</td>
<td>n.a</td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>VAR</td>
<td>1.007</td>
<td>n.a</td>
<td>3.416</td>
<td>n.a</td>
<td></td>
</tr>
<tr>
<td>South Korea</td>
<td>V ECM</td>
<td>0.427</td>
<td>3.449**</td>
<td>0.786</td>
<td>1.156</td>
<td></td>
</tr>
</tbody>
</table>

Note: The coefficients of regressors have been estimated by VAR or V ECM. Numbers in the cells of the independent variable (“X”) are chi-square statistics and numbers in the cells of ECT are asymptotic t-statistics, which are used to interpret the statistical significance of the parameters. The probability value for rejection of the null hypothesis is employed at the 1% significant level (***, p-value < 0.01), the 5% significant level (**, p-value < 0.05) and the 10% significant level (*, p-value < 0.1).

Table 3 displays the results of Granger causality tests with annual data. The null hypothesis regarding no causation leading from ICT development to economic growth in the short-run cannot be rejected for all the three countries. The null hypothesis regarding no causation leading from economic growth to ICT development in the short-run can be rejected only for China at the 5% significance level. The results are consistent with different lag selections, but the numeric values of the results of different lag selections are not reported in this study. Considering the results of the Granger causality test in Table 3, this study concludes that Hypothesis 2 “ICT development leads to economic growth” is not supported for all the three countries in this study. Hypothesis 3 “Economic growth leads to ICT development” is supported only for the China case. In other words, due to the presence of one-way directional causal relationship from economic growth to ICT development for China this finding suggests that economic growth leads to ICT development in China.

DISCUSSION AND CONCLUSION

Unlike the empirical findings of the previous studies, the Granger causality test in this study does not support the hypothesis of ICT-led economic growth in the short-run for all the three countries in this study. Given that China, Japan and South Korea have been showing relatively export-led growth economies, in terms of ratios of economic growth compared to that of ICT development; it is rational to believe that the ICT development of such countries is strongly affected by the industrial structures in such conditions. The results of this study also find a one-way causal relationship from economic growth to ICT development for China. Some of the possible reasons why the growth-led ICT development hypothesis is true for China are that economic development would be beneficial for ICT development in China and ICT development is strongly affected by growth of the Chinese economy in such conditions.

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Considering that the findings of this empirical study differ among the three countries, the inconsistent results may indeed be a reflection of the specific countries’ stage of economic development. Because countries could be different in terms of both the weight of the ICT industry in the overall economy and the size and openness of the economy, therefore the ICT-led growth hypothesis could also differ from one country to another. The diverse relationships between ICT development and economic growth in different country settings found in existing empirical studies further support that country-specific conditions influence the results. Therefore, a careful empirical analysis is desirable for any country that may want to focus on the ICT industry as part of its national economic development strategy. The analysis will verify if the common notion that the ICT-led growth is in fact applicable to that particular country. Based on the results of this study, decisions on the ICT-led economic growth strategy can be adjusted or altered for such factors as the overall ICT investments and ICT infrastructure budget, approval of private or governmental ICT projects, and so forth.

In sum, the results of the causality test can help the government set priorities regarding where and how to use limited resources for national economic growth. If empirical results support the ICT-led growth hypothesis in the short-run, more resources should be allocated to the nation’s ICT industry as a priority rather than to other sectors. This allocation of resources is appropriate in the case of South Korea since ICT-boosting policies as a means of economic growth will be fully effective in the long-run. If an economic growth-led ICT development holds true, the government should allocate resources to leading industries and not to ICT directly so that the overall economy will be improved and the ICT industry will benefit from economic growth, which is appropriate in the case of China.

To detect the causal relationship, this study performed Granger causality tests following the cointegration approach, which has been the typical method favored in studies of this kind. The current study discovered mixed results between ICT development and economic growth in the three Northeast Asian countries. Note that empirical results on the causal relationship between the two variables have been inconsistent in the past. The mixed results indicate that the direction of causality between ICT development and economic growth may be determined by various factors of the country. In conclusion, factors for each country such as the degree of dependence on the ICT industry, the usage of ICT and the level of economic development may each be considered individually as important determinants.

The mixed results of this study further point to several research directions for the future. First, the simple bivariate VAR and VECM models were used in this study. The important and critical roles that other macroeconomic factors play in model specifications were not fully considered. This can be improved by adopting an approach of using multivariate Granger causality tests to include important variables such as foreign direct investment, exports and some socio-economic factors. Second, the limitations of this study may be related to data availability. Instead of using a series of mobile and fixed-line telephone subscribers (per 100 people) information, the more accurate measure of ICT development generated from economic impact data, so called credible instruments, will produce more precise causal relations.

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EPQ FOR THE PRODUCT OF LIMITED PRODUCTION

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ABSTRACT
Consumers’ perceived value and purchase decisions are usually influenced by the scarcity. Limited production quantity is an important strategy for the marketing manner, which many industries often use in recent years. Exclusive outlet distribution and higher pricing are common practices for promoting business and increasing profit. In this study, we consider a newsvendor problem model with limited production quantity: both the unit selling price and customers’ demand are influenced by the limited production quantity. An algorithm is developed to derive a production policy such that the expected profit is maximized. Numerical examples and sensitivity analysis are presented to illustrate the model.

Keywords: Limited production quantity, Newsvendor, Scarcity.

INTRODUCTION
Scarcity is a pervasive aspect of human life and is a fundamental precondition of economic behavior [1]. Consumers often consider scarce products as possessing higher values, which triggers them to desire these products even more. Accordingly, the manufacturers design their marketing strategies and shape the products to seem scarce, which would attract consumers and increase their interest in purchasing. This type of marketing strategy is very common among current industries. For example, department stores announce limited products on their promotional flyers during their anniversary sales, which require customers to take numbers and to wait in line on certain days.

Commodity theory [2] deals with the psychological effects of scarcity. The theory’s principle claim is that “any commodity will be valued to the extent that it is unavailable”. According to the theory, scarcity enhances the value (or desirability) of anything that can be possessed, is useful to its possessor, and is transferable from one person to another [1]. The need for uniqueness may vary across differing situations and persons; as such, a high need for uniqueness may be related to (a) forces in a given situation that promote an extreme sense of high similarity, and (b) dispositional factors that influence the high need for uniqueness across a variety of situations [3]. Sirgy [4] addressed the importance of scarcity in marketing strategy. Salespersons should apply such strategy while merchandising products or services, which may increase the motivation of the targeted customers to approach the promotional information. There are two strategies for price raise through scarcity: (1) direct result from the quality and symbolic interest, and (2) indirect result on quality and symbolic interest through the price. As a result, raising the prices of scarce products can make a positive impact, but also may backfire as customers perceive that they are paying more money [5]. Therefore, if we combine the commodity theory and the need for uniqueness theory, we can demonstrate that customers prefer possessing scarce product to show their uniqueness, compared to possessing common and easily-available products. We can also clearly demonstrate the reason why limited products can always trigger customers’ desire to purchase.

Limited production quantity is an important strategy for the effect of scarcity which is usually single production. Recently many industries use this strategy frequently. This problem is well known as the “newboy problem” or the “newsvendor problem”. The newboy problem, also known as the single period stochastic inventory model [6,7], is found to be a suitable tool for decision-making regarding stocking issues in today’s supply chains [8]. Weng [9] analyzed the coordinated quantity decisions between the manufacturer and the buyer in a newsvendor model. Dominey and Hill [10] explored the effectiveness of a number of approaches for approximating a compound Poisson distribution in a newsvendor model. Wang and Webster [11] used loss aversion to model manager’s decision-making behavior in the single-period newsvendor problem. Shi et al. [12] presented an extension to the multi-product newsvendor problem by incorporating the retailer’s pricing decision, as well as considering supplier quantity discount. However, to the best of our knowledge, little researches had been found on the newsvendor problem including limited production quantity issues. For such reason, this study analyzes the newsvendor problem with limited production quantity.

In this study, the supplier manufactures the products and then sells to the retailer, or directly sells to the customers. The supplier has to consider the uncertainty in customers’ need. Marketing the products with limited-edition and
manufacturing an optimal quantity before the selling period of the product are vital to the supplier. An algorithm is presented to derive an economic production quantity and the unit selling price such that the expected profit is maximized.

**NOTATIONS**

The following notations are used in our analysis:

- \( E\pi \): the expected profit for the supplier
- \( Q \): the production quantity for the supplier; decision variable
- \( Q^* \): the economic production quantity (EPQ) for the supplier considering limited production quantity
- \( Q'_c \): the economic production quantity for the supplier without considering limited production quantity
- \( p_1 \): the selling price per unit without considering limited production quantity; constant
- \( p_2 \): the upper bound of selling price per unit when the production quantity is limited; constant
- \( P(Q) \): the selling price per unit with considering limited production quantity; which is a function of production quantity
- \( c_p \): the production price per unit; \( c_p < p(Q) \)
- \( s \): the salvage value per unit \( s < c_p \)
- \( r \): the shortage cost per unit; represents costs of lost goodwill
- \( x \): the random demand with the PDF (Probability Density Function), \( f(x) \), and CDF (Cumulative Distribution Function), \( F(x) \); in this study, \( x \) is uniformly distributed

**MODELING AND ASSUMPTIONS**

In this section, we formulate the expected profit model for the supplier. Throughout this study, single production of this product–edition is assumed. The supplier manufactures a batch of the products, \( Q \), and sells to the retailer or sells directly to customers. The unit production price of the product is \( c_p \). The unit selling price is \( P(Q) \). When the sale quantity is less than the batch \( Q \), the leftover is sold with the unit salvage value \( s \). When the demand is more than or equal to the batch, \( Q \), the shortage occurs. In here, shortage backordered is not allowed and the shortage unit cost is \( r \). If the selling price \( P(Q) = p_1 \) (that is, without considering variable selling price), and with the uncertainty in the customers' demand to be \( x \), the supplier will manufacture an optimal batch of the products, \( Q^*_c \), according to its optimal expected profit. This is the traditional newsvendor problem. The suppliers’ expected profit function \( E\pi \) is:

\[
E\pi(Q^*_c) = \int_0^{Q^*_c} \left[ p_1 - c_p \right] \left[ x - (c_p - s)(Q^*_c - x) \right] f(x) dx + \int_{Q^*_c}^{\infty} \left[ p_1 - c_p \right] \left[ Q^*_c - (x - Q^*_c) r \right] f(x) dx. \tag{1}
\]

The suppliers’ optimal production batch follows (Hadley and Whitin, 1963):

\[
F(Q^*_c) = \frac{(p_1 - c_p + r)}{(p_1 - s + r)} \tag{2}
\]

where \( F(x) \) is the CDF of \( x \). If the supplier manages the production batch of the products (that is, limited production quantity) for marketing and business purposes, then the consumers’ perceived value and purchase decisions are usually influenced by the effect of scarcity. Furthermore, the unit selling price, \( P(Q) \), of the limited quantity products can be increased, where \( P(Q) \) is a decreasing function of \( Q \). However, the customer demand will decrease due to the higher selling price simultaneously. Thus, in this study the random demand of Uniformly distributed over the range 0 and \( B(Q) \) is assumed, where \( B(Q) \) is an increasing function of \( Q \) (it is because the higher production batch will decrease the selling price, while the lower selling price will increase the demand). That means the PDF, \( f(x) \), of the random demand, \( x \), depends on \( Q \). The suppliers’ expected profit function \( E\pi \) is given as follows:

\[
E\pi(Q) = \int_0^{Q} \left[ p_1 - c_p \right] \left[ x - (c_p - s)(Q - x) \right] f(x) dx + \int_{Q}^{B(Q)} \left[ p_1 - c_p \right] \left[ Q - (x - Q) r \right] f(x) dx. \tag{3}
\]
Our problem can be formulated as:

$$\text{Max: } E\pi(Q).$$

(4)

For the maximum of the function, to prove its concavity is needed. Due to the complexity of $E\pi(Q)$, it is implausible to prove. We then investigate the model by an illustrative case study.

AN ILLUSTRATIVE CASE STUDY

In this section, the practical selling price and probability distribution are used to explain the results of the previous section. Since the selling price is always influenced by the limited production quantity (Wu & Hsing, 2006), therefore, the selling price per unit $P(Q)$ is assumed as

$$P(Q) = \frac{p_2-p_1}{\sqrt{Q}} + p_1, \quad p_1 > p_0 > 0, \quad Q \geq 1.$$  

(5)

Which means both $p_1$ and $P(Q)$ is a decreasing function of $Q$. The random demand for the supplier is uniformly distributed over the range $0$ and $B(Q)$, where

$$B(Q) = \frac{b\pi_1}{P(Q)},$$

(6)

is a function of $Q$ with positive constant $b$. It means that the higher selling price would decrease the demand. Thus, the PDF of the supplier’s demand is

$$f(x) = \frac{1}{B(Q)}.$$  

(7)

Two cases are discussed as follows.

(i). General case

In this case, $B(Q) = b\pi_1/P(Q)$, one has

$$E\pi'(Q) = \int_0^Q [P'(Q)x - c_p + s]f(x)dx + \int_0^{B(Q)} [P'(Q)+P(Q)-c_p+r]f(x)dx + B'(Q)f(B(Q))\left\{ P'(Q)\frac{B(Q)}{P(Q)} - \left[ B'(Q) - 0 \right] \right\}. $$

(8)

$E\pi(Q) = \int_0^Q xf(x)dx + \int_0^{B(Q)} f(x)dx - \left[ P(Q) - s + r \right] f(Q).$

$$+ \left[ P(Q) - c_p \right] \left[ B(Q) - 0 \right] f'(B(Q)) $$

$$+ 2B'(Q) \left[ P(Q) + P(Q) - c_p + r \right] f(B(Q)).$$

(9)

From (10), it is implausible to prove the concavity of $E\pi(Q)$. The numerical examples are provided to illustrate the model.

Example 1. Given $p_2=250$, $p_1=130$, $c_p=100$, $b=1500$, $s=50$, and $r=5$.

The concavity of $E\pi(Q)$ is illustrated in Figures 1, 2, and 3. Figure 1 presents the shape of $E\pi(Q)$, which reaches the maximum in the interval $[500, 1000]$. Figure 3 presents the shape of $E\pi(Q)$, which obtains its negative value. That means the concavity of $E\pi(Q)$. Figure 2 presents the shape of $E\pi'(Q)$, which means the root of $E\pi'(Q) = 0$ is located in the interval $[500, 1000]$. Set $E\pi'(Q)$ equals to zero, using Software Maple 8, $Q^*$=614 is derived, the selling price per unit is $P(Q^*)=134.8$, and the optimal expected profit for the supplier is $E\pi(Q^*)=5913.7$. When limited production quantity is not considered, $Q^*=618$ (using Eq.(2)). $E\pi(Q_{so})=57059$ (using Eq.(1)), and the percentage profit increase is $\frac{E\pi(Q^*)}{E\pi(Q_{so})}-1=29.4\%$.

![Figure 1](image)

FIGURE 1. The shape of $E\pi(Q)$ in example 1.
(ii). Special case

In this case, without considering variable selling price, that is, \( P(Q) = p_1 \) and \( B(Q) = b \). That is, \( f(x) = \frac{1}{b} \). One has

\[
E\pi'(Q) = \int_0^b [P'(Q)x - c_p + s]f(x)dx
\]

\[
+ \int_b^Q [P'(Q)Q + P(Q) - c_p + r]f(x)dx
\]

\[
= P'(Q)\int_0^b F(x)dx + [P(Q) - s + r]F(Q)
\]

\[
- [P(Q) - c_p + r]Q - P'(Q)(Q).
\]

(10)

Where \( F(x) \) is the CDF of r.v. \( x \).

\[
E\pi''(Q) = P'(Q)\int_0^b x^2 f(x)dx
\]

\[
+ \int_b^Q \left[ P'(Q)Q + P(Q) - 2c_p + 2s + r \right] f(x)dx
\]

\[
- [P(Q) - 2c_p + 2s + r]Q - P'(Q)(Q).
\]

(11)

The concavity and optimal solution of \( E\pi(Q) \) are derived in Theorem 1.

**Theorem 1.** For the random demand \( X \sim U(0,b) \) with the selling price function \( P(Q) = \frac{p_2 - p_1}{\sqrt{Q}} + p_1, Q \geq 1 \), the expected profit function \( E\pi(Q) \) is concave.

Proof: (Please see Appendix A)

From Theorem 1, the economic production quantity \( Q^* \) can be derived by setting

\[
E\pi'(Q) = 0.
\]

(12)

**Example 2.** Given \( p_2 = 250, p_1 = 130, c_p = 100, b = 1500, s = 50, \) and \( r = 5 \).

Set \( E\pi'(Q) \) equals to zero, using Software Maple 8, \( Q^* = 633 \) is derived, the selling price per unit is \( P(Q^*) = 134.8 \). Using Eq.(3), the optimal expected profit for the supplier is \( E\pi(Q^*) = 9434 \). When limited production quantity is not considered, using Eq.(2),

\[
F(Q^*) = \frac{Q^*}{b} = \frac{633}{1500} = \frac{p_1 - c_p + r}{p_1 - s + r} = 0.412, Q^* = 618 \text{ is derived.}
\]

Using Eq.(1), \( E\pi(Q_{w1}) = 7059, \) and the percentage profit increase is \( \frac{E\pi(Q^*)}{E\pi(Q_{w1})} - 1 \times 100\% = 33.7\% \).

**CONCLUSION**

This study derives a newsvendor problem model with limited production quantity. Analyzing the system provides managerial insights on how to develop strategies for making the greatest profit. An illustrative case study, numerical examples, and sensitivity analysis are presented to demonstrate our argument. Numerical examples show that the percentage profit increase is fairly significant. Further researches are suggested to consider different selling period and the distribution of customers’ demand.
REFERENCES


Appendix A

Proof of Theorem 1

\[ E\pi^*(Q) = p^*(Q)\int_0^Q xf(x)dx + \left[p^*(Q) + 2p'(Q)\right] \times \int_Q^\infty f(x)dx - \left[p(Q) - s + r\right]f(Q) \]

\[ = \frac{-1}{8bQ^{(2/3)}} \left[8Q^{(2/3)}(p_1 - s + r) + 3Q(p_2 - p_1) + 2b(p_2 - p_1)\right]. \]

Since \( p_1 - s > 0 \), and, \( p_2 - p_1 > 0 \), therefore, \( E\pi^*(Q) \leq 0 \), the proof is completed.
INFLUENCE OF RESOURCE-BASED CAPABILITY AND INTER-ORGANIZATIONAL COORDINATION ON SUPPLY CHAIN MANAGEMENT FOCUS

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ABSTRACT

This article explored the effect of resource-based capability and inter-organizational coordination on a firm’s supply chain management focus. We proposed a conceptual framework to describe these two sets of antecedents. The hypotheses were tested using confirmatory factor analysis and multiple linear regression on a set of data collected in the U.S., Europe, and New Zealand. Test results revealed the positive relationships between the proposed antecedents and a firm’s supply chain management focus.

Keywords: Resource-based view, supply chain management focus, inter-organizational coordination.

INTRODUCTION

Over the last two decades, business scholars have dedicated considerable effort to understand the factors that encourage organizations to adapt supply chain management (SCM). SCM stresses the seamless coordination of value-creating activities across organizational boundaries to bring products and services to end users. It encompasses inherent complexity and intricacy. The primary question raised in the literature pertains to why firms in a supply chain choose to coordinate their activities with supply chain members to compete in the global marketplace. This question has motivated many influential studies on the genesis of the SCM focus of manufacturing firms and retail organizations, such as the transaction cost economics and resource-based views. In this study, we define SCM focus as the extent of a firm’s concentration on various SCM activities, including its efforts to reduce response time and improve integration activities across the supply chain. Faced with intense competition and rapidly shrinking product life cycles, manufacturers and service providers realize that seamless process coordination with those of supply chain partners can be an indispensable competitive edge. Thus, inter-organizational coordination has become increasingly adapted as a pivotal tool to eliminate waste across the supply chain.

Coordination effect arises when firms engage in global SCM activities. Firms use cross-organizational coordination in a global marketplace to overcome the challenges of penetrating a new market and the liability of dealing with overseas supply chain members. In this context, the term “inter-organizational coordination” embraces all types of coordination that buyers and suppliers accumulate through their supply chain activities and implies their ability to explore, analyze, and act on supply chain issues in both buyer and supplier perspectives. As such, buyers and suppliers continuously strive to explore their resources collectively to achieve competitive capability with supply chain members and, in turn, improve their SCM focus.

In supply chain content, inter-organizational coordination is the media through which managers gain access to a variety of resources; for example, inter-organizational coordination helps buyers and sellers access information and resources in the supply chain and reduces perceived risk through explicit certification or associations. Reliance on inter-organizational coordination is not constrained to the new entry to the supply chain but also include information and resource acquisition. Inter-organizational coordination that constitutes relational networks encompasses both economic and noneconomic activities that are embedded in supply chain integration [1].

The principal feature of inter-organizational coordination is that it inheres in the relationship between supply chain members rather than in physical assets, like financial capital, and in the collection of inter-firm networks that supply chain members maintain in varying contexts. In this context, inter-organizational coordination provides a source of competitive advantage in the supply chain and, from a transaction cost economics view, a source of profit-generation capability, because it connects those who control necessary input with others to generate (non-tradable) input and form groups that can design and enforce cost-saving business activities throughout the entire supply chain [2].

Despite its importance, the effect of inter-organizational coordination on SCM focus remains an under explored area. In response, we empirically examine the antecedents of SCM focus by integrating the traditional resource-based view with inter-organizational coordination, while controlling for context factors. Because both perspectives have considerable merit; thus for a complete understanding of the SCM focus of manufacturing firms and retail organizations, researchers and managers must consider them simultaneously. However, these two perspectives also compete with one another in explaining SCM focus. Is inter-organizational coordination more important, or is a resource-based view the key determinant of SCM focus? In this study, we explicitly assess the relative impact of these two sets of factors on SCM focus.

Several studies have addressed different firm-level factors that contribute to the SCM focus of a firm [2]. However, this study is unique in the following respect: We focus on the added value of taking an inter-organizational coordination perspective, which we consider not as a substitute factor but rather a complement to existing knowledge that enables us to build on previous findings based on resource-based view. The article is organized as follows: The next section describes the conceptual framework and research hypotheses. Next, we describe the research methodology and discuss the results. This study concludes with a delineation of the significance of the findings, managerial implications, and limitations.
THEORETICAL BACKGROUND

To guide the subsequent discussion, we depict the key constructs included in this study in Figure 1. This research proposes that the two sets of antecedents, pertaining to a traditional resource-based view and inter-organizational coordination, precede SCM focus of a firm, and controls for company context factors. The fundamental principle of the resource-based view is that the basis for a firm’s competitive advantage lies primarily in the application of its valuable resources. On the basis of our literature review, we propose that both the traditional resource-based view (which pertains to product innovation capability, inventory control capability, and quality control capability), and inter-organizational coordination (which pertains to business information coordination, business decision coordination, and business process coordination) precede SCM focus. The central theme of the research model therefore argues that considering the SCM antecedents on both perspectives simultaneously can lead to a better understanding of the factors that affect the SCM focus of manufacturing retail firms.

Inter-organizational coordination in a supply chain context refers to the extent to which firms coordinate their value-adding activities across the supply chain to eliminate waste and improve efficiency. Coordinated activities can be tactical (e.g., purchasing, operations scheduling, and logistics) or strategic (e.g., long-term corporate objectives, marketing and customer information). Prior research on the importance of inter-organizational coordination has shown that coordination enhances visibility and reduces uncertainty [4]. It allows firms to coordinate across their supply chains, allowing them to collaborate in activities such as sales, production, and logistics [5]. The extent to which coordination is conducted creates opportunities for firms to work collaboratively to remove supply chain inefficiencies, and thus has a significant direct impact on the relationship among supply chain members. The ability to coordinate across the supply chain can also provide other opportunities. For example, when additional business information becomes available, firms can take advantage of this increased visibility to modify existing actions or plan future operations.

In advancing the key role of inter-organizational coordination in SCM, [6] discusses how firms build and utilize informal channel coordination to achieve effective SCM. [7] proposes that supply chain members’ economic action is embedded in their ongoing network of coordination. Through formal and informal channels, inter-organizational mechanisms facilitate information sharing, which helps match buyers, sellers, and other business partners. Furthermore, sharing information about labor and material costs, and market conditions with suppliers enhances the profitability of an investment project and thus is crucial for investment decisions.

HYPOTHESIS DEVELOPMENT

Resource-based Antecedents

The first set of antecedents we address pertains to resource-based factors, which comprise the three components: product innovation capability, inventory control capability, and quality control capability (Figure 1).

The first resource-based antecedent pertains to product innovation capability. Several studies have demonstrated a significant relationship between SCM and product innovation capability. [8] shows that research and development intensity...
for product innovation capability and the percentage of revenue generated from its product innovation are directly related to the levels of global sourcing activity. [9] proposes that purchasing and supplier involvement in product innovation create a source of competitive advantage. [10] shows that early supplier involvement in product innovation leads to significant improvements in product development across the supply chain. [11] analyzes the relationship between product innovation and SCM and presents a conceptual model of the determinants of product innovation in SCM. It is clear that the literature suggests a relationship exists between product innovation capability and SCM focus. [12] states that a firm that actively involves key suppliers in product innovation must effectively manage its supply chain. Sharing information, technology, and risk are all contingent on having sound relationships with potential partners. Effectively incorporating suppliers’ parts into product innovation capability requires evaluation of how they will interface in the firm’s SCM focus. The potential for cost savings and quality improvements will be limited if there is not a shared understanding of how partners plan to align their individual goals to meet shared objectives. We hypothesize,

\[ H_1: \text{Product innovation capability positively affects SCM focus.} \]

The second antecedent we address pertains to the inventory control capability. [9] argues that supply chain efficiency is contingent on the effectiveness and ability of individual supply chain members to connect along the supply chain. [13] studies SCM from an inventory control perspective, focusing on linkages between supply chain members and the chain’s collective efficiency. [14] reports that manufacturers use inventory control methods to achieve sustainable competitive advantage and propose an integrated inventory management model that is useful for managing inventory control in an environment where supply chain members form strategic alliances for the purpose of profit sharing. [15] discusses the importance of rapid delivery of products, and how inventory control manufacturing principles can be applied to SCM practices. [16] reports that inventory control capability affects a firm’s SCM practices and savvy manufacturers are expected to deliver raw materials and component parts in small lot sizes, frequently, and directly to the point of use, thus eliminating the need for non-value adding inspection of incoming materials. Many organizations adopt strategic alliances with key suppliers to share confidential information and technology. Instead of relying on inspection of incoming materials and component parts, they certify suppliers’ processes and/or products. A firm that is advanced in its inventory control capability is likely to place significant emphasis on such practices [17]. Based on these observations we hypothesize,

\[ H_2: \text{Inventory control capability positively affects SCM focus.} \]

The third antecedent we address pertains to the quality control capability. [18] examines the relationships among quality control, certification, and SCM and reports that quality is a strategic variable that should be considered and managed not only within individual firm, but also across the supply chain. [19] explores the connections between buyer and supplier quality assurance practices and highlight the importance of a company-wide commitment to the application of quality assurance principles across the supply chain. [20] discusses the relationships between quality control and dimensions of SCM. [21] reviews and tests the relationship between quality control and SCM and conclude that failure to consider the impact of quality control programs helps to explain the inadequacies of existing SCM models. The literature suggests that a firm’s quality control capability affects its SCM focus. The rationale for this relationship is obvious. For example, a firm that is advanced in its quality control practices is more likely to select suppliers that are similarly competent in their quality control capability, and is motivated to form alliances with such suppliers and to allow key suppliers to participate in its product innovation initiative. Conversely, a firm that is less advanced in its quality control capability is unlikely to be able to do so due to its lack of internal capability, motivation to enhance its quality control capability, and credibility in the eyes of suppliers [17]. We therefore hypothesize,

\[ H_3: \text{Quality control capability positively affects SCM focus.} \]

Inter-organizational Coordination Antecedents

The second set of antecedents of SCM focus pertains to inter-organizational coordination factors which comprise business information coordination, business decision coordination, and business process coordination.

Business information coordination enhances the coordination of knowledge with supply chain members and increases the ability to serve downstream supply chain members efficiently. This coordinated information includes changes in market demand, and customer preferences, and helps to coordinate transaction-related activities. This coordinated information is characterized in multiple dimensions, including timeliness, accuracy, completeness, and information credibility [22]. Coordination can be facilitated by the use of coordinated information systems that enable firms to obtain better, more timely information, and thereby maintain close, mutually beneficial coordination [23]. Having such systems also sends a signal to supply chain members about a firm’s willingness and commitment to work together towards common goals, a key element of effective coordination. Business information coordination thus provides the ‘glue’ that not only binds individual pairs of firms, but firms across the supply chain [24]. Thus, we posit,

\[ H_4: \text{Business information coordination positively affects SCM focus.} \]

The second inter-organizational coordination antecedent pertains to business decision coordination. Business decision coordination provides visibility and reduces uncertainty along the supply chain [25]. Suppliers need to understand buyers’ needs and their decision-making processes to effectively respond to changes in the marketplace. For example, a retailer’s sharing of point-of-sale data with manufacturers and distributors, or using collaborative planning, forecasting and replenishment systems, provides a context within which upstream partners can interpret market

The 11th International DSI and the 16th APDSI Joint Meeting, Taipei, Taiwan, July 12 – 16, 2011, pp.359-366
behavior [26]. This allows firms to reduce differences in derived demand forecasts, inventory levels, and costs associated with the ‘bullwhip effect’. The result is an improved responsiveness in the supply chain which can in turn positively enhance buyer-supplier relationships [27]. The literature suggests that not only does a supplier’s understanding of a buyer’s decision-making processes affect the success of buyer–supplier relationships [28], so does coordinated decision-related information, particularly when underlying demand is significantly correlated, especially when replenishment lead times are long. Hence, we posit,

\[ H_5: \text{Business decision coordination positively affects SCM focus.} \]

The third antecedent pertains to business process coordination. Among the motivations for business process coordination are the potential benefits associated with enhanced business data processing [29]. For example, information technology that facilitates data processing and transfer among supply chain members ranges from low technology applications such as telephones and fax machines, to sophisticated technologies [30]. Among these technologies, electronic data interchange (EDI) is a key tool because of its ability to transmit large amounts of data more rapidly and accurately than traditional paper-based methods [31]. Its open standards have motivated some firms to move their EDI systems to the internet and to develop internet protocol-based EDI systems. Several studies have shown that business process coordination like EDI application can facilitate supply chain coordination and promote relationship building [32]. Thus, we posit,

\[ H_6: \text{Business process coordination positively affects SCM focus.} \]

RESEARCH METHODS

Questionnaire Administration

Data were collected in three regions, the U.S., Europe, and New Zealand. Respondents were identified from the Institute for Supply Management (ISM) and the Association for Operations Management (APICS) membership lists, and the KOMPASS commercial database. We sent surveys to the senior purchasing or supply chain managers of 6,097 sample firms. Ninety-one surveys were returned undelivered due to incorrect addresses or the respondents having left the firms. Next, a reminder letter was mailed to the respondents two weeks after the first mailing. Four weeks after the initial mailing, all remaining non-respondents received a second follow-up letter, a duplicate questionnaire, and another stamped, self-addressed envelope. These combined efforts produced 596 responses yielding a roughly ten percent response rate. We assessed potential non-response bias through a series of t-tests to compare mean differences of early and late respondents in terms of firm characteristics and the constructs used in this study. The results suggest no significant differences between early and late respondents on the key variables.

In the survey data, four hundred and eleven respondents were from the U.S., 116 were from Europe, and the remaining 69 firms were from New Zealand. About 44 percent of our respondents were final product manufacturers, and 37 percent were wholesalers and retailers. Forty-seven percent of our respondents have annual gross sales exceeding $50 million.

Constructs and Measurement Items

To achieve a high degree of validity, we used multiple indicators to represent each latent construct and employed existing scales whenever possible. The product innovation capability construct includes four items that reflect the importance of factors that affect a firm’s product innovation capability. We measure inventory control capability with four items that ask respondents to rate the extent to which their firm has the necessary JIT capabilities in their operations. Four indicators measure quality control capability, for which informants indicate the extent to which the management stresses the importance of quality control practices.

For business information coordination, we use six items that ask the managers to indicate the extent to which their firm share and integrate information with other supply chain members. The business decision coordination construct has six items that ask informants to indicate the extent to which each item applies to their business decision behavior. Three items measure business process coordination that asks informants to indicate the extent to which they integrate their operations processes with supply chain members. SCM focus consists of seven indicators that examine the extent of a firm’s SCM efforts. In the survey, respondents were asked to indicate whether their firms have a formal strategic alliance program with key suppliers because we expect the SCM focus of a firm with formal strategic alliance program is likely to differ from those that do not have one. This study controls for the existence of formal strategic alliance programs and country-of-origin effects.

STATISTICAL ANALYSES AND RESULTS

Measure Validation

Confirmatory factor analysis (CFA) was used to assess the psychometric properties of the scale items for the constructs derived from the survey instrument. Psychometric properties of the survey instrument in terms of reliability and construct validity were evaluated. Construct validity is concerned with the appropriateness of the underlying structure of a construct and can be assessed by determining the empirical dimensions of the construct using principal components factor analysis. Confirmatory factor analyses were used by combining individual set of measured items into the appropriate factors, and factor scores were saved for subsequent analysis. The items had factor loadings of between 0.606 and 0.877 on their respective factors. Reliability analysis was carried out using Cronbach’s α to assess the internal consistence of the scales. Values of α in excess of 0.50 show that given the exploratory nature of the analysis, the scales can be considered to be sufficiently reliable. Cronbach’s α values ranged from .742 to .862 for the seven constructs (see Table 1).
Hypotheses Testing Results

This study uses the factor scores of each construct for the hierarchical regression analysis. This analysis enables us to examine the hypothesized direct effects of the traditional resource-based view and inter-organizational coordination on SCM focus when we isolate the control factors. We first include the control variables (i.e., strategic alliance program and whether the firm is based in the U.S.) in the hierarchical multiple linear regression analysis to control for the effects of strategic alliance programs and country-of-origin effect, and then incorporate the explanatory variables in the full model. Table 2 presents the SCM focus regression results.

Table 2: Hierarchical Multiple Linear Regression

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>SCM Focus (Models)</th>
<th>A(^2)</th>
<th>B(^2)</th>
<th>C(^2)</th>
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<tbody>
<tr>
<td><strong>Control Variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strategic Alliance Program</td>
<td>-3.46(^2)</td>
<td>.140(^2)</td>
<td>.088(^2)</td>
<td></td>
</tr>
<tr>
<td>U.S. &amp; non-U.S. Firms</td>
<td>-2.01(^2)</td>
<td>-.185(^2)</td>
<td>-.133(^2)</td>
<td></td>
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<tr>
<td><strong>Resource-based Capability</strong></td>
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<td></td>
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<td></td>
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<tr>
<td>Product Innovation</td>
<td>H(_1)</td>
<td>.290(*)</td>
<td>.118(*)</td>
<td></td>
</tr>
<tr>
<td>Inventory Control</td>
<td>H(_2)</td>
<td>.195(†)</td>
<td>.020(†)</td>
<td></td>
</tr>
<tr>
<td>Quality Control</td>
<td>H(_3)</td>
<td>.133(†)</td>
<td>.059(†)</td>
<td></td>
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<tr>
<td><strong>Inter-organizational Coordination</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Business Information</td>
<td>H(_4)</td>
<td>.456(‡)</td>
<td></td>
<td></td>
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<tr>
<td>Business Decision</td>
<td>H(_5)</td>
<td>.189(‡)</td>
<td></td>
<td></td>
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<tr>
<td>Business Process</td>
<td>H(_6)</td>
<td>.120(‡)</td>
<td></td>
<td></td>
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<tr>
<td>F-value</td>
<td>8.461</td>
<td>20.863</td>
<td>37.791</td>
<td></td>
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<tr>
<td>R(^2)</td>
<td>.044</td>
<td>.241</td>
<td>.491</td>
<td></td>
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<tr>
<td>Adjusted R(^2)</td>
<td>.039</td>
<td>.229</td>
<td>.478</td>
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<tr>
<td>Δ in Adjusted R(^2)</td>
<td>-</td>
<td>.190</td>
<td>.249</td>
<td></td>
</tr>
</tbody>
</table>

* significant at \(\alpha = 0.10\)
† significant at \(\alpha = 0.05\)
‡ significant at \(\alpha = 0.01\)

In models A, B and C, the dependent variable, SCM focus, is regressed on the control and independent variables. Model A (F-value = 8.461, \(p < .01\)) tests the effects of the two control variables on SCM focus. Model B (F-value = 20.863, \(p < .01\)) adds the main effects of the three resource-based predictors. It explains an additional 19.0% more variance than by the control variables in model A. Hypothesis H\(_1\) predicts that product innovation capability relates positively to the SCM focus, is supported (\(\beta = .290, p < .01\)). Also, the inventory control capability is positively related to SCM focus, in support of H\(_2\) (\(\beta = .195, p < .01\)). Moreover, quality control capability has a significant positive impact on SCM focus, in support of H\(_3\) (\(\beta = .133, p < .05\)). Model 3 (F-value = 37.791, \(p < .01\)) adds the main effects of inter-organizational coordination to the regression analysis, which explains an additional 24.9% more variance than that offered by the control and resource-based variables in model B. The analysis in model C supports H\(_4\) that business information coordination has a significant positive impact on SCM focus (\(\beta = .456, p < .01\)). We also find strong support for H\(_5\) (\(\beta = .189, p < .01\)) that business decision coordination and H\(_6\) (\(\beta = .120, p < .05\)) that business process coordination significantly affect SCM focus.

**DISCUSSION**

Most studies hint that SCM focus is as much a function of the character and background of the firm as of the resources it possesses. The bulk of scholarly investigation of SCM focus is on how firm-specific variables (such as capability) are relevant in enhancing performance, but relatively little research attention focuses on the role of inter-organizational coordination in forming SCM focus, especially in the context of manufacturing firms and retail organizations. This study uses an alternative framework to explain that focus. Toward this end, we analyze the impact of traditional resource-based and inter-organizational coordination on a firm’s SCM focus to determine which factor provides a stronger explanation for the differing focus of a firm’s SCM practices. Our analysis of survey data validates our major premise that inter-organizational coordination plays crucial roles in SCM focus. Our test results confirm the significant positive associations between the two sets of antecedents and SCM focus to suggest that inter-organizational coordination offers an alternative perspective to explain a firm’s SCM focus.

Specifically, all three resource-based capabilities alone are essential for explaining a firm’s SCM focus (see model B), but product innovation capability is the only construct that predicts the SCM focus (see model C) when we incorporated the three components of inter-organizational coordination. That is, product innovation capability is a significant and positive predictor in all regression models examining SCM focus. However, inventory control capability and quality control capability are not significant factors in explaining SCM focus when inter-organizational coordination factors are added (see models C). Overall, the result in regression model 3 suggests that inter-organizational coordination is more important in explaining a firm’s SCM focus than resource-based capability. The result does not contradict the findings of transaction cost economics or the resource-based view that suggests firm-specific resources explain the SCM focus. Instead, it supplements the literature by showing that,
in the case of today’s competitive supply chain environment, traditional explanations of antecedents may not paint a complete picture of successful SCM focus. Our finding confirms the significant role of inter-organizational coordination. On the basis of these findings, we conclude that both resource-based capability and inter-organizational coordination play an important role in a firm’s SCM focus. In particular, resource-based capability helps to integrate a firm’s internal functions, such as purchasing, supply management, operations management, marketing, logistics, and physical distribution to create an internally integrated supply chain. Once the internal functions within the four walls of a firm are seamlessly integrated, the organization can extend outward to exploit its inter-organizational coordination competence to integrate with upstream suppliers and downstream customers. Thus, the resource-based capacity is a set of internal competency, whereas the latter serves as unique assets to link manufacturing firms and retail organizations in a supply chain.

**MANAGERIAL IMPLICATIONS**

This study has several unambiguous implications for managers and policymakers. The literature review reveals that a firm’s SCM focus is the result of various simultaneous factors. In particular, superior SCM practices depend on both traditional resource-based capability and inter-organizational coordination. Hence, managers must possess the necessary resources for supply chain participation and to develop key capabilities to enhance their SCM focus. Our results, which consistently show the significant influence of firm resources, mandate that firms in a supply chain in the modern competitive global market possess the necessary resources for supply chain participation and development of unique capabilities if they want to achieve superior performance.

In addition, the nature and extent of inter-organizational coordination precede SCM focus. Thus, savvy managers operating in a complex supply chain can develop an efficient SCM focus if they align inter-organizational coordination with inimitable resources. Increased globalization forces supply chain managers to think beyond the traditional resource-based perspective and to consider other relevant factors that may help them improve efficiency across their supply chain. In this regard, managers must recognize that their firms are not just an economic unit but also a human-based entity. Such recognition is the first step to open the door to a set of potentially available inter-organizational coordination activities. Manufacturers and service firms can wield these inter-organizational coordination competencies in the global supply chain if they understand their sources and how to explore inter-organizational coordination within and across the supply chain. While it is essential to exploit the potential of inter-organizational coordination to eliminate waste, such as relying on supplier certification in place of inspecting inbound raw materials, savvy managers must realize that it is impossible to integrate with external supply chain members unless the functional divisions within their own firm are integrated internally. For example, a supplier will not be able to ship directly to the point of use if the operations manager does not share his daily production information with the purchasing manager. When its functional divisions are integrated internally, then the firm can expand its integration effort outward to include supply chain members beyond the four walls of its organization.

The major points of this study are summarized in Figure 2. The three inimitable resource-based capabilities (inventory control, product innovation, and quality control capabilities) are unique to a firm. At the initial stage of SCM, each resource-based capability helps to integrate the various functional divisions within an organization to eliminate duplicate activities and remove waste. For example, exceptional inventory control capability helps both the supply management and the physical distribution divisions of a firm to reduce its raw materials and finished-goods inventory. Simple inventory control concepts, such as reducing the supplier base, utilizing preventive maintenance, and increasing the delivery frequency help to trim down raw materials, work-in-process, and finished-goods inventory. A firm can also exploit its extraordinary product innovation capability by linking its supply and operations management functions in new product design and development. Supply management can utilize early supplier involvement, whereas the operations management function can take advantage of concurrently engineering, parts simplification, and value analysis or value engineering to reduce product development time and cost while simultaneously improve product quality.

**Figure 2: Internal and External Factors Affecting SCM Focus**

Internal supply chain is used in the literature to describe a firm in the supply chain with well-integrated functional divisions, whereas an integrated supply chain is used to describe two or more supply chain members that have coordinated their value-added activities. Once a firm has successfully exploited its resource-based capability to form an internal supply chain, the next logical step is to expand its SCM focus to embrace external supply chain members to achieve an integrated supply chain [33]. In order to synchronize its activities with external supply chain members, a firm must rely on various forms of inter-organizational coordination, such as business information, decision, and process coordination. The coordination is needed to link the firm with its strategic suppliers and customers. For example, a buying firm must share its production scheduling information with suppliers if the buying firm requires the suppliers to ship in small lot-sizes directly to the point of use frequently. In the just-in-time shipping concept where purchased materials are shipped in small lot sizes directly to

*Hsu, C.C., Tan, K.C. & Cross, J.*

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the point of use, it is impossible for the buying firm to inspect any incoming raw materials. Therefore, prior to the formation of an integrated supply chain, an efficient internal supply chain with exceptional production innovation, quality control, and inventory control capabilities must be in place. This may be a plausible reason that once the inter-organizational coordination predictors are entered into the multiple linear regression model in Table 2, two of the three resource-based capabilities became insignificant (Model C). In summary, the resource-based capability can be viewed as the internal factors, and inter-organizational coordination is the external factors affecting the SCM focus.

LIMITATIONS

This study attempts to offer a theoretical framework to explain the complex SCM focus of manufacturing firms and retail organizations in a supply chain. Such endeavors are ambitious in nature and therefore contain numerous inherent limitations. First, the most significant potential limitation of this study is the range of developed constructs for inter-organizational coordination. Our study incorporates multiple rounds of theory building through literature reviews and expert opinions, but it does not capture every aspect of inter-organizational coordination. Establishing a valid and reliable instrument to capture these multiple facets represents an ongoing process, and no psychometric technique can address the completeness or breadth of the measurement adequately. It is entirely possible that other dimensions of inter-organizational coordination affect foreign market expansion decisions but are not captured herein.

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REFERENCES


MANAGING SUPPLY CHAIN DISRUPTION RISKS

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ABSTRACT

This paper analyzes the optimal set of suppliers in the presence of supplier and/or production failure risks. We incorporate the importance of cash-flow variability in the supplier selection and production planning process. The financial loss caused by disasters, the operating cost of working with multiple suppliers and unfilled demand cost are subject to uncertainty. We formulated optimization problems with different objective functions whose solution determines an optimal set of suppliers. Our result allows management to balance the two desirable but conflicting objectives of cost minimization and service levels achieved.

Keywords: Supply Chain, Risk Management, Suppliers' Failure, Production Failure, Unfilled Demand, Service Level.

1. INTRODUCTION

Recently, the interest of supply chain risk management (SCRM) has increased in purchasing, logistics and supply chain management research (e.g., Berger et al (2004) and Ruiz-Torres and Mahmoodi (2007), Lee (2008), Meena et al (2011)). Random customers' demand and unanticipated supply disruption or supply risk is a fact in business. Some of the undesirable outcomes associated to its occurrence are firm's inability to meet customers' demand or cause disruption to the operation of the organization. Clearly, supplier selection process is a critical component of supply chain risk management given the reliance of many organizations on suppliers to manage their inventories and logistics functions. Therefore, it is important for businesses to manage their supply risk.

Model that uses mean value analysis (e.g., expected total cost) is not suitable for analyzing the effect of traditional risk management tools such as insurance on the optimal suppliers selection process. This is due to the fact that insurance premium typically include some extra loading which account for administrative expenses and profit (e.g., Harrington and Niehaus (2004)). Thus, a model only consider expected total cost would consider buying insurance as costly since the premium cost more than the expected loss. On the other hand, the mean-variance approach allows us to recognize the effect of insurance coverage reduces the variability of the cash-flow. Effectively, buying insurance increases the expected cost but it reduces the variability of the cash-flow and the risk reduction provided by insurance may allow the firm to increase its use of debt with tax-deductible interest payments. Furthermore, reducing variability of cash-flow increases the value of the firm. This is the trade-off that our model able to capture whereas models based on expected cost would not be able to do so.

This article aims to extend current SCRM knowledge by analyzing the impact of supplier failures as well as the effect of demand uncertainty on the supplier selection process. Our focused on SCRM lead us to measure the risk and uncertainty regarding the loss and operating cost associated with a set of suppliers. In particular, we obtained the mean and variance of the cost function. This result allows us to determine a set of optimal suppliers that minimized the cost incurred. Clearly, cost is only one factor in choosing a set of suppliers. Service levels provided by the suppliers is important as well. Cost minimization and service levels are two important yet conflicting factors. The proposed methodology also aims to balance these two conflicting objective. Thus, this paper represent a step toward achieving the goal of understanding how an organization can survive and thrive under unanticipated supply disruptions taking into considerations of important factors such as cost and service levels.

2. THE MODEL

The supply chain includes m groups of suppliers and a production system. There are $n_i$ suppliers in group $i$; $i = 1, 2, ..., m$. Each of the m group supplies a unique type of input to the production system. That is any suppliers in group $i$ can only supply input $i$. The production process requires all m types of input in order to produce products to satisfy demand. In this paper, we are interested in analyzing the impact of supply disruption risk and the operations risk impose by uncertain production process as well as random demand for the finish goods.

To model supply disruption risk, we assume that there are potential super-events that can occur and affecting all suppliers simultaneously. That is, events such as terrorism or a widespread airline action that put all suppliers down. Let $S$ denote the indicator random variable associated with the super-events. We assume that $S$ equal to 1 if a super-event occur during the supply cycle and 0 otherwise. The probability of one of these super-events occurring during the supply cycle is denoted by $P(S = 1) = p$. We introduce a unique-event scenario for each supplier; that is, an event uniquely associated with a particular supplier that
puts it down during the supply cycle. Let $D_{ij}$ denote the indicator random variable associate with the unique event of $i^{th}$ supplier in group $j$. That is $D_{ij} = 1$ if the $i^{th}$ supplier in group $j$ is down during the supply cycle and 0 otherwise. We designate the probability that $i^{th}$ supplier in group $j$ is down as $P(D_{ij} = 1) = d_{ij}$. By definition of super-events and unique-event, the $S$ and $D_{ij}'s$ are assume to be independent random variables. We also define semi-super events as events that affect a subset of all suppliers but not all suppliers. Basically, one implicitly assumed that if some (but not all) of the suppliers in a group are down then the other suppliers in that group would be utilized to fill the needs. Effectively, for the suppliers, we restrict ourselves to three possible states of nature: (i) at least one group of suppliers is down (i.e., the production system can’t engage in production due to lack of input), (ii) at least one supplier is up for each of the m groups and some suppliers are down and (iii) no suppliers are down. Notice that in the latter two cases, the production system is productive. However, the costs incurs for the two cases are not the same. Specifically, case (ii) should include the extra cost of getting the up suppliers to fill the order that are unable to deliver by the fail suppliers.

Given that the production system received all $m$ types of input, the production system will engage in production to satisfy demands. To model operations risk for the production system, we let $Z$ denote the indicator random variable associated with the event that some demand is not met during the production cycle given that the required supplies was delivered. Notice that demand is not met during the production cycle may be due to a variety of reason (e.g., inefficient/inadequate production during the production cycle, uncertainty of demand, etc). We assume that $Z$ equal to 1 if some demand is not met during the production cycle and 0 otherwise. The probability of some demand is not met during the production cycle is denoted by $P(Z = 1) = z$. We can and do interpret $z$ as the stock-out probability during the cycle.

For our model, the demand will not be met if any of the following scenarios occurs

1. The super-event or at least one group of suppliers is down (i.e., the production system can’t engage in production due to lack of input),
2. some suppliers are down; the production system is productive and demand is not completely filled and
3. no suppliers are down; the production system is productive and demand is not completely filled.

We let $L_i^j$; $i = 1, 2, 3$ denote the financial loss to the decision-making company associated with scenario $i$. For example, we can and do interpret One may interpret $L_1$ as the total loss suffers by the company when the production system can’t engage in production due to failure of some group of suppliers in delivering the require input. One may interpret $L_3$ as the partial loss in comparison to the total loss suffers when there is minor supply disruption (i.e., at least one supplier is up from each of the m groups and at least one supplier is down). One may interpret $L_3$ as the financial loss due to inability to meet demand given that the production system engages in production. We assume that for each $i = 1, 2, 3$; $L_i$ is a positive random variable with first and second moments given by $E(L_i) = l_i$ and $E(L_i^2) = l_i^{(2)}$. By definition, we have $L_1 \geq L_2 \geq L_3$. Thus, it is natural to assumed that $l_1 > l_2 > l_3$.

For each $i \in \{1, 2, ..., m\}$, let us define $J_i \equiv \{1, 2, ..., n_i\}$ as the set of all available supplier in group $i$, $|J_i| = n_i$, and

$$J \equiv \{J_1, J_2, ..., J_m\}. \quad (1)$$

Suppose we have $K = \{K_1, K_2, ..., K_m\} \subseteq J$ (i.e., $K_i \subseteq J_i$ for all $i$). Let us denote the cost of operating or working with suppliers set $K$ by $C_o(K)$. Let $G_{ij}$ denote the cost of including or maintaining supplier $i$ in group $j$ as part of the supply chain. We assume that $G_{ij}'s$ are independent nonnegative random variables with $E(G_{ij}) = g_{ij}$ and $E(G_{ij}^2) = g_{ij}^{(2)}$. We also assume that for each supplier set $K \subseteq J$, $C_o(K) \equiv a + \sum_{j=1}^{m} \sum_{i \in K_j} G_{ij}$. \quad (2)

**Remark 1:** The functional form of $C_o(K)$ given by the above equation is assume to simplify the analysis to follows. In general, $C_o(K)$ is an increasing function of $G_{ij}'s$; for all $i, j$.

Noticed that loss occurred due to four sources, (i) the super-events, (ii) at least one group of suppliers is down during the supply cycle, (iii) at least one supplier is up for all groups and some suppliers are down during the supply cycle and unable to meet demand, and (iv) no suppliers is down during the supply cycle and unable to meet demand. The first two cases dealt with total loss $L_1$. The third case dealt with partial loss $L_2$ and the last case dealt with partial loss $L_3$. Thus, the loss costs associated with supplier set $K$, $C_l(K)$ can be represented by
For the special case of \( m = 1 \) or the single supplier case, the second term in the above equation equal to 0.

That is, there is no partial loss in the case of single supplier. Combining equation (1)-(2), we see that for each set of suppliers \( K \subseteq J \), the total cost function can be written as

\[
C(K) = C_{I}(K) + C_{o}(K)
\]

\[
= L_{1}(S + (1 - S)[1 - \Pi_{j=1}^{m}(1 - \Pi_{i\in K_{j}}d_{ij})])
+ (L_{2} + L_{3}Z)(1 - S)\Pi_{j=1}^{m} \Pi_{i\in K_{j}}(1 - d_{ij})
\times \left[ \Pi_{j=1}^{m}(1 - \Pi_{i\in K_{j}}d_{ij}) - \Pi_{j=1}^{m} \Pi_{i\in K_{j}}(1 - d_{ij}) \right]
+ L_{3}Z(1 - S)\Pi_{j=1}^{m} \Pi_{i\in K_{j}}(1 - d_{ij})
+ a + \sum_{j=1}^{m} \sum_{i\in K_{j}} G_{ij}
\]

\[
= \sum_{j=1}^{m} \sum_{i\in K_{j}} [g_{ij}^{(2)} - g_{ij}^{2}]
\]

\[
Var(C_{o}(K)) = \sum_{j=1}^{m} \sum_{i\in K_{j}} [g_{ij}^{(2)} - g_{ij}^{2}]
\]

\[
Var(C_{I}(K)) = l_{1}(p + (1 - p)[1 - \Pi_{j=1}^{m}(1 - \Pi_{i\in K_{j}}d_{ij})])
+ (l_{2} + l_{3}Z)(1 - p)\Pi_{j=1}^{m} \Pi_{i\in K_{j}}d_{ij}
\times \left[ \Pi_{j=1}^{m}(1 - \Pi_{i\in K_{j}}d_{ij}) - \Pi_{j=1}^{m} \Pi_{i\in K_{j}}d_{ij} \right]
\]

\[
Var(C(K)) = E(C_{o}(K)) + E(C_{I}(K))
\]

\[
Var(C(K)) = Var(C_{o}(K)) + Var(C_{I}(K)).
\]

To simplify the analysis to follows, for each group \( j \) let us order the failure probabilities \( d_{ij}^{*} \) so that

\[
d_{ij}^{*} \leq d_{2j}^{*} \leq ... \leq d_{n,j}^{*} \quad \text{for} \ j = 1, 2, ..., m.
\]

With the above ordering, let us define

\[
I_{m} \equiv \{(k_{1}, k_{2}, ..., k_{m}) \mid 1 \leq k_{i} \leq n_{i} \text{ and } k_{i} \text{ is integer for all } i\}
\]

and for \( K = (k_{1}, k_{2}, ..., k_{m}) \subseteq I_{m} \), let

\[
C_{o}(K) \equiv a + \sum_{j=1}^{m} \sum_{i=1}^{k_{j}} G_{ij},
\]

\[
C_{I}(K) \equiv L_{1}(S + (1 - S)[1 - \Pi_{j=1}^{m}(1 - \Pi_{i\in K_{j}}d_{ij})])
+ (L_{2} + L_{3}Z)(1 - S)\Pi_{j=1}^{m} \Pi_{i\in K_{j}}(1 - d_{ij})
\times \left[ \Pi_{j=1}^{m}(1 - \Pi_{i\in K_{j}}d_{ij}) - \Pi_{j=1}^{m} \Pi_{i\in K_{j}}(1 - d_{ij}) \right]
+ L_{3}Z(1 - S)\Pi_{j=1}^{m} \Pi_{i\in K_{j}}(1 - d_{ij})
\]

\[
C(K) \equiv C_{o}(K) + C_{I}(K)
\]

Clearly, \( C_{o}(K) \), \( C_{I}(K) \) and \( C(K) \) are respectively the operating cost, loss cost and the total cost associated with the first \( k_{i} \) suppliers for all \( m \) groups under the ordering given by equation (6).

**Remark 1:** Equations (7)-(10) are define with respect to the ordering given by equation (6).

### 3. Analysis

In this section, we shall present our analysis of the optimal suppliers’ selection problem based on the model presented in section 2. In particular, we present a few formulations to our supply chain risk management problems under different performance criterions.

**3.1. Mean-Variance approach to finding an Optimal Set of Suppliers**

We aim to find a set of supplies which minimizes the cost incurred. Toward this goal, we formulate the following optimization problem (OP1)

\[
\text{Min}_{K \subseteq J} E(C(K)) + \theta \sqrt{Var(C(K))}
\]

where as usual, \( \theta \) represent the weight that measure our attitude towards risk.

**Remark 2:** (i) For the special case of \( m = 1 \), \( \theta = L_{2} = L_{3} = z = 0, n_{1} = \infty \), (OP1)
reduces to the problem analyzed by Berger et al. (i.e., unlimited suppliers and mean value analysis without possibility of partial loss and no production/demand uncertainty). (ii) For the special case of \( m = 1, L_3 = \infty, n_1 = \infty \), (OP1) reduces to the problem analyzed by Lee (i.e., Lee 2008, unlimited available suppliers and single type of input with no production/demand uncertainty).

In this general form, (OP1) is a complicated combinatorial optimization problem. We propose to examine numerically a variety of cases aimed at understanding supplier failure risk versus total cost behavior. These numerical results also allow us to analyze the impact of risk and uncertainty on the optimal number of suppliers to be included in each of the \( m \) groups.

### 3.2. Balancing Service Level and Cost approach to finding an Optimal Set of Suppliers

(OP1) aims to select an optimal set of suppliers so as to minimize cost taken into consideration the variability of cash flow. However, service level is of importance to the company as well. Thus, one is led naturally to balance two important and possibly conflicting objectives, service level and cost. This leads us to formulate the problem as one that maximize service level subject to a given budget constraint.

#### Suppliers’ Service Level

The production process requires all \( m \) types of input in order to produce products to satisfy demand. Since total loss (i.e., the production system can’t engage in production due to lack of input) occurs due to two sources, the super-events \( S \) and the unique events that resulted in at least one group of suppliers failed to deliver supply. Noticed that given a set of suppliers \( K = \{K_1, K_2, ..., K_m\} \subseteq J \), the probability that group \( i \) successfully deliver supply to the production/distribution system is equal to

\[
P(\text{suppliers in group } i \text{ deliver supply}) = 1 - P(\text{all suppliers in group } i \text{ fails}) = 1 - \Pi_{i \in K_i} d_{ij}.
\]

Thus, we get the probability that all \( m \) groups successfully deliver supply to the production/distribution system is

\[
P(\text{all groups deliver supply}) = \Pi_{i=1}^{m} (1 - \Pi_{i \in K_i} d_{ij}).
\]

and at least one group of suppliers failed to deliver supply is equal to

\[
P(\text{at least one group of suppliers failed to deliver supply}) = 1 - \Pi_{i=1}^{m} (1 - \Pi_{i \in K_i} d_{ij}).
\]

Thus, given a set of suppliers \( K = \{K_1, K_2, ..., K_m\} \subseteq J \), the probability that total loss occurs is given by

\[
P(\text{suppliers’ loss}(K)) = P(\text{super-event}) + P(\text{no super-event})
\]

\times \ P(\text{at least one group of suppliers failed to deliver supply})

\[
= p + (1 - p)[1 - \Pi_{i=1}^{m} (1 - \Pi_{i \in K_i} d_{ij})].
\]

Therefore, we may define service level associate with a given set of supplier \( K \subseteq J \) as

\[
\text{SSL}(K) \equiv 1 - P(\text{suppliers’ loss}(J))
\]

\[
= (1 - p)\Pi_{j=1}^{m} (1 - \Pi_{i \in K_i} d_{ij}).
\]

Notice that the suppliers’ service level is a product of two probabilities; probability that the super-event did not occur during the cycle and probability that the production system received the required inputs to engage in production.

#### System’s Service Level

We define system’s service level as the probability of meeting demand in a (supply + production) cycle. The production system needs to receive the required inputs from all \( m \) groups of suppliers. Given that the production system receives the require supply, the probability that demand is not filled is \( z \). Thus, we see that there are two possibilities where the demand may not be filled; (1) The production system did not received the require inputs from at least one of the suppliers’ group, and (2) the production system received the require inputs from the suppliers and the demand is not filled. The probability that the production system did not received the require inputs from at least one of the suppliers’ group is given by

\[
P(\text{Super-event})
\]

\[
+ \ P(\text{no Super-event})
\]

\times \ P(\text{at least one group of suppliers failed to deliver})

\[
= p + (1 - p)[1 - \Pi_{i=1}^{m} (1 - \Pi_{i \in K_i} d_{ij})].
\]
production system failed to meet demand given that all group of suppliers deliver necessary supplies

\[(1 - p)\prod_{i=1}^{m} (1 - \Pi_{j \in K_j} d_{ij}) z.\]

Thus, given a set of suppliers \( K \subseteq J \) we see that probability of not meeting demand in a given cycle is

\[
P(\text{not meeting demand}(K)) = p + (1 - p)[(1 - \Pi_{j=1}^{m} (1 - \Pi_{i \in K_j} d_{ij})]
+ (1 - p)\prod_{j=1}^{m} (1 - \Pi_{i \in K_j} d_{ij}) = 1 - (1 - p)(1 - z)\prod_{j=1}^{m} (1 - \Pi_{i \in K_j} d_{ij}).
\]

(16)

Therefore, given a set of suppliers \( K \subseteq J \) we may set the total system service level as the capability of meeting demand

\[
TSSL(K) \equiv 1 - P(\text{not meeting demand}(K)) = (1 - p)[\prod_{j=1}^{m} (1 - \Pi_{i \in K_j} d_{ij})](1 - z) = SSL(K)(1 - z).
\]

(17)

Notice that the suppliers’ service level is a product of three probabilities: probability that the super-event did not occur during the cycle, probability that the production system received the required inputs to engage in production and the probability that demand will be met during the cycle given that the production system engage in production.

Let \( B \) represent our budget allocated to operate the suppliers and handle the loss incurs. The following optimization problem (OP2) aims to select a set of suppliers that maximized the total system service level and stay within the allocated budget as well as achieved minimum suppliers’ service level

\[
\text{Max}_{K \subseteq J} \quad TSSL(K) \quad \text{s.t.} \quad E(C(K)) + \theta \sqrt{Var(C(K))} \leq B \quad \text{and} \quad SSL(K) \geq \beta
\]

(18)

3.3. Target Service Level approach to finding an Optimal Set of Suppliers

The constraint of (OP2) is really a probabilistic constraint. It is possible that the constraint of (OP II) is satisfied but the real cost still exceed \( B \). This is due to the risk and uncertainty associated with the loss amount or the operating cost. Furthermore, it is natural for a firm to impose a minimum acceptable service level. Thus, as an alternative to (OP2), one may seek a set of suppliers that minimized cost and achieved certain target service level.

Let \( \delta \) be the minimum acceptable or targeted service level.

The resulting optimization problem is (OP3)

\[
\text{Min}_{K \subseteq J} \quad E(C(K)) + \theta \sqrt{Var(C(K))} \quad \text{s.t.} \quad TSSL(K) \geq \delta
\]

(19)

Clearly, the maximum service level is obtained by using all the available suppliers. Thus, from equations (1), (16)-(17), we see that maximum total system service level is given by

\[
MTSSL \equiv (1 - p)[\prod_{j=1}^{m} (1 - \Pi_{i \in J_j} d_{ij})](1 - z).
\]

(20)

Therefore, a given target service level \( \delta \) can be achieve if and only if

\[
(1 - p)[\prod_{j=1}^{m} (1 - \Pi_{i \in J_j} d_{ij})](1 - z) \geq \delta.
\]

(21)

Thus, (OP3) is feasible if and only if equation (21) holds.

4. NUMERICAL RESULTS – IDENTICAL SUPPLIERS

In this section, we assume the case of identical suppliers with 5 groups of 3 suppliers. Specifically,

\[
m = 5, n_1 = n_2 = n_3 = n_4 = n_5 = 3, \quad \text{and} \quad |J| = \sum_{i=1}^{m} n_i = 15.
\]

(22)

Furthermore, we assume deterministic loss and operating cost. Therefore, we also have

\[
g_{ij} = g_1, \quad g_{ij}^{(2)} = g_2, \quad \ell_{1}^{(2)} = \ell_1, \quad \ell_{2}^{(2)} = \ell_2, \quad \ell_{3}^{(2)} = \ell_3 \quad \text{for all} \quad i \text{ and} \quad j.
\]

(23)

Thus, the problem of locating optimal set of suppliers reduces to finding the optimal number of suppliers. We use the following base case parameter values

\[
l_1 = 500, \quad l_2 = 150, \quad l_3 = 50, \quad g_1 = 10, \quad p = 0.01, \quad d = d_{ij} = 0.05 \quad \text{and} \quad z = 0.05
\]

(24)

When one of the parameter’s value is changed, it is assumed that all of the other parameters stay at the base value, unless otherwise noted. The entry of \( x \) in Tables 1-8 means that \( x \) suppliers are selected for each of the 5 groups. Tables 1-4 tabulate our numerical results given by solving (OP1) and Tables 5-8 tabulate our numerical results given by solving (OP3). Table 1 consider sensitivity analysis when the value of \( l \) changes. Table 2 consider sensitivity analysis when the value of \( g_1 \) changes. Table 3 consider sensitivity analysis when the value of \( p \) changes. Table 4
consider sensitivity analysis when the value of \( d \) changes. For each of these 4 tables, we tabulate the value of optimal number of suppliers \( n^* \) with three values of \( \theta = 0, 1, 2 \). The case \( \theta = 0 \) represents the case of mean value analysis.

**TABLE 1-Optimal \( k_v \): Sensitivity Analysis of the value of loss, \( l_1 \)**

<table>
<thead>
<tr>
<th>( d = 0.05 )</th>
<th>( d = 0.2 )</th>
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<tbody>
<tr>
<td>( l_1 )</td>
<td>( \theta = 0 )</td>
</tr>
<tr>
<td>350</td>
<td>1</td>
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<tr>
<td>800</td>
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<td>1200</td>
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<td>4000</td>
<td>2</td>
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<td>5000</td>
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</table>

**TABLE 2-Optimal \( k_v \): Sensitivity Analysis of the value of \( \sigma_1 \)**

<table>
<thead>
<tr>
<th>( d = 0.05 )</th>
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</thead>
<tbody>
<tr>
<td>( \sigma_1 )</td>
<td>( \theta = 0 )</td>
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<tr>
<td>1</td>
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<tr>
<td>4</td>
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<td>10</td>
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<td>16</td>
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<td>25</td>
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**TABLE 3-Optimal \( k_v \): Sensitivity Analysis of the value of \( p \)**

<table>
<thead>
<tr>
<th>( p )</th>
<th>( \theta = 0 )</th>
<th>( \theta = 1 )</th>
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<tbody>
<tr>
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<tr>
<td>0.5</td>
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<tr>
<td>0.6</td>
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</tbody>
</table>

**TABLE 4-Optimal \( k_v \): Sensitivity Analysis of the value of \( d \)**

<table>
<thead>
<tr>
<th>( d )</th>
<th>( \theta = 0 )</th>
<th>( \theta = 1 )</th>
<th>( \theta = 2 )</th>
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<tr>
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<tr>
<td>0.3</td>
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From Tables 1-4, we observe that the mean value analysis consistently underestimated the optimal number of suppliers when one takes into consideration the variability of the cashflow.

Tables 5-8 tabulate optimal solution of (OP3) with targeted service level of \( \delta = 90\% \). Using equation (22)-(24), and (20), we see that the maximum service level is 93.99\%. Thus, (OP3) is infeasible for \( \delta \geq 94\% \). In Tables 7-8, \( x=\infty \) means that (OP3) is infeasible. In Tables 5-8 we find many cases where imposing the targeted service levels increase the optimal number of suppliers. Therefore, we see that imposing a targeted service level in choosing the optimal number of supplier could change the solution drastically.

**TABLE 5-Optimal \( k_v \): Sensitivity Analysis of the value of loss, \( l_1 \)**

<table>
<thead>
<tr>
<th>( d=0.05, \delta = 0.9 )</th>
<th>( d=0.20, \delta = 0.9 )</th>
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</thead>
<tbody>
<tr>
<td>( l_1 )</td>
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<td>4000</td>
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<tr>
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5. SUMMARY

We have proposed a mean-variance approach to determine the optimal number of suppliers in the presence of supplier failure risks. In particular, we have provided three formulations for the optimal supplier group selection problem. Our formulation of the problem generalizes the analysis proposed by Lee (2008). It allows us to take into consideration the issues of multiple groups of suppliers, limited number of available suppliers, and the impact of meeting random demand. We also provided some numerical results for the special case of five groups of identical suppliers. The results are tabulated in Tables 1–4. We also show that imposing targeted service level could increase the optimal number of suppliers and in some cases render the problem infeasible. The results are tabulated in Tables 5–8.

6. REFERENCES


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**TABLE 6**- Optimal \( \theta \); Sensitivity Analysis of the value of \( \theta \), \( \delta = 0.9 \)

<table>
<thead>
<tr>
<th>( \delta = 0.05 )</th>
<th>( \delta = 0.20 )</th>
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<tbody>
<tr>
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**TABLE 7**- Optimal \( \theta \); Sensitivity Analysis of the value of \( p \)

<table>
<thead>
<tr>
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**TABLE 8**- Optimal \( \theta \); Sensitivity Analysis of the value of \( d \)

<table>
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<td>2 ( \theta = \Omega )</td>
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<tr>
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<td>2 ( \theta = \Omega )</td>
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<tr>
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<td>3 ( \theta = \Omega )</td>
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<td>0.2</td>
<td>3 ( \theta = \Omega )</td>
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<tr>
<td>0.25</td>
<td>inf ( \theta = \Omega )</td>
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</table>
ASEAN AUTOMOTIVE SUPPLY CHAIN MANAGEMENT (SCM): ENTREPRENEURIAL SCM COMPETENCE AND PERFORMANCE

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ABSTRACT

The purpose of this study is to discover the dimensions of a new construct called the entrepreneurial supply chain management competence. We measured entrepreneurial SCM competence in terms of five first-order constructs: innovation orientation, proactiveness orientation, risk-taking characteristics, relational capital, and coordination capability. We further proposed that this competence affects SMEs’ performance directly and indirectly via the firm’s SCM strategies. A set of survey data collected from automotive OEM suppliers in five ASEAN countries was used to test the research model. Results show that the five constructs are important dimensions of entrepreneurial SCM competence, and that it affects performance indirectly. Our findings provide valuable insights about the enablers of an SME’s SCM practices and their effects on firm performance.

Keywords: Entrepreneurship, supply chain management, competence, performance.

INTRODUCTION

In this immensely competitive global environment, many firms resort to supply chain management (SCM) as a core strategic competence to gain competitive edge. The philosophy behind SCM stresses the seamless integration of value-creating activities across organizational boundaries to bring products and services to market. Although SCM exists in many different forms, depending on the levels of integration, individual performance, and industries, its key objective invariably is to create an inter-organizational, boundary-spanning strategy that enables both buyers and suppliers to integrate their activities to eliminate waste.

Despite the positive influences of SCM on firm performance though, research has shown that organizations that participate in the supply chain in the same market segment can experience dramatically different performance levels [1]. Unfortunately, there is a lack of research to explore the linkage between SCM competence and performance, especially among small and medium-sized enterprises (SMEs). Hence, the fundamental question pertains to the intangible resources that firms can employ to engage successfully in a supply chain. This question has motivated many influential theories on the genesis of SCM behavior, including the resource-based view, transaction cost economics, and social exchange theory.

These theories focus primarily on large manufacturing firms; no theory pertains to the SCM behavior of SMEs. This trend is understandable, because for much of the 20th century, large manufacturing firms occupied the dominant share of the world economy. However, by the early 1990s, SMEs accounted for more than half of the domestic economic activity in most developed nations. For example, in the U.S. manufacturing sector in 2000, SMEs accounted for 98 percent of all manufacturers and employed two-thirds of the workforce [2]. The share of manufacturing SMEs continues to increase as they continue to create more jobs and generate faster growth rates than large manufacturers.

Despite the growing salience of SMEs, little research looks into the intangible resources that these firms deploy to thrive, especially with respect to supply chains. SMEs are not simply smaller versions of large firms [3]. Since they lack the size and diverse resources that large firms possess, especially in the capital- and technology-intensive industries, SMEs lack the advantage of massive resources when they engage in a supply chain [4]. Instead, they are constrained by their limited resources, lack of brand recognition, and imperfect management. These characteristics constitute significant barriers and influence the behavior of SMEs because a minute mistake can cause a small firm to collapse [5]. Hence, SMEs that intend to engage in SCM must rely on unique advantages, probably distinctly diverse from those discovered in research of large firms, to overcome their size- and resource-related disadvantages [6].

This study attempts to contribute to the SCM and entrepreneurship literature by exploring this gap. First, we examine the role of a specific entrepreneurial SCM competence, which we define as the inimitable SCM capability for recognizing and pursuing business opportunities that engender success and growth. Business competences have become central research themes for organizational strategy and performance literature, but little empirical research aims to uncover the bundles of SCM competences that may characterize the innovative processes underlying entrepreneurial success among the countless firms in a supply chain. Current knowledge in this area is fragmented and incomplete, and the benefits for firms that are competent in the supply chain, or what it takes to achieve this competence, is not yet clear.

Second, to extend the knowledge in this area, we first seek to establish whether a parallel exists between literature in entrepreneurship and SCM. Several key tenets from entrepreneurial literature are representative of more nascent attributes of supply managers. Table 1 illustrates the specific capabilities are applicable to SCM and entrepreneurship from the different theoretical perspectives of transaction cost economics, resource-based view, and social capital theory. We therefore begin with an overview of entrepreneurship literature and interview practitioners to describe specific
attributes of entrepreneurs that align with features of supply managers. We also conceptualize a new construct, entrepreneurial SCM competence, which incorporates key firm characteristics and factors that collectively should enhance firm performance. To study the impact of entrepreneurial SCM competence on firm performance, we conduct a series of interviews and identify specific factors that reflect entrepreneurial SCM competence in SMEs. Third, based on our findings from the literature review and interview with practitioners, we develop a research model to analyze the direct and indirect intervening effects of entrepreneurial SCM competences on SCM strategies and firm performance. Thus, we attempt to contribute to the SCM and entrepreneurship literature by linking an antecedent and mediator in a cohesive manner to SMEs’ performance.

In the following section, we provide a rationale for the emergence of entrepreneurship in SCM. We then summarize relevant literature and conceptualize the concept of an entrepreneurial SCM competence based on our proposed theoretical model. Next, we develop a set of hypotheses to assess the validity of our study, explain our research method, and test the hypotheses by means of a survey-based study. Finally, we report our findings, and conclude the study with several managerial implications and suggestions for future study.

THEORETICAL BACKGROUND

What drives firms to engage in supply chain management initiatives? Marketing and operations management researchers disagree on the rationale for the dynamics of supply chain activities [7]. Moreover, there is no single theoretical framework that can clarify the antecedents of SCM strategies [1]. We use the resource-based view (RBV) to identify a set of factors that might encourage firms to conduct business in a supply chain. In particular, the RBV assumes that gaining and preserving a sustainable competitive edge is a function of the firm’s core resources and capabilities. These resources and capabilities are the key source of a firm’s success, and heterogeneity in organizational resources leads to varied competitive advantages and performance [8]. The RBV also explains how organizational competences, and thus capabilities, may develop and leverage within enterprising firms [9].

Because of the differences between SMEs and large firms, especially in terms of their tangible resources, we argue that business competences internal to the manufacturing SME are distinctive and specific for achieving supply chain success. As trade barriers fell rapidly over the last decade, global supply chain and logistics capabilities advanced rapidly. At the same time, the complexity and uncertainty of the global market environment created greater supply chain risk, such as the risks associated with perceptions, cultural differences, organizational learning, e-business, information security, supplier opportunism, and dependence [10].

The uncertain returns on supply chain-related business activities imply an entrepreneurial firm in a supply chain is willing to bear some uncertainty [11] [12] [13]. A thriving SME operating in a complex supply chain must possess some form of unique entrepreneurial SCM competence to compete against large, multinational organizations. Manufacturing SMEs may exhibit specific entrepreneurial resources, in the form of orientations and competences that are helpful for implementing effective supply chain management. Aligning entrepreneurial and SCM practices is crucial to achieving positive corporate outcomes. Corporate entrepreneurial activities might also complement SCM practices.

Entrepreneurship refers to a process of opportunity recognition and pursuit that leads to growth, including opportunistic activities that create value and bear risk, which means it is firmly associated with innovation [14]. However, entrepreneurship research is not restricted to

| Table 1 | Alignment between Supply Chain Management and Entrepreneurship Roles |
|-----------------|-------------------|------------------|------------------|
| **Transaction Cost Economics** | **Resource-Based View** | **Social Capital Theory** |
| **Entrepreneurial SCM Competence** | **Entrepreneurial Opportunism** | **Entrepreneurial Social Capital** |
| Firms engaging in SC are driven by the objective of profit maximization and cost efficiencies [15]. Relationships between buyers and suppliers lower transaction costs and facilitate investments in relation-specific assets [16]. If a supplier can produce at lower cost than the buyer and the differential is greater than the sum of transaction related costs, engagement in SC is preferred [17]. Transaction costs depend on the ability of the supplier to meet buyer expectations [18]. If there is a mutually beneficial interest between buyer and suppliers, opportunism will no longer be a concern for the buyer even when highly specific assets are involved [19]. | SC member has developed internal operations capabilities and infrastructure; it is in a position to leverage relationships within the SC [22]. Collaborative, inter-firm development of SC capabilities affects performance [23]. SCM capabilities, like just-in-time delivery and quality control, contribute to superior inventory performance in SC [24]. A firm’s SCM resources enable it to conceive and implement SC strategies, thereby improving its effectiveness and performance [25]. Firms that want to offer goods and services at lower cost and higher quality must integrate and coordinate their operations capabilities with multiple supply chain members across a vast, complex set of tasks [26]. | Buyer-supplier relationships also play a crucial role in reducing uncertainties in the business exchange process [32]. Buyer-supplier relationship research provides extensive evidence of the positive effect of these relationships on SC practices [33]. In a SC, through formal and informal communication channels, social networks may facilitate information sharing, which helps match buyers and sellers or other business partners [34]. Sharing information about labor and material costs, suppliers, distributors, and other market conditions could reveal the profitability of an investment, which is crucial for SC decisions [35]. Social capital is important in developing a cooperative strategy and thus an inter-organizational competitive advantage [36]. |
| **Entrepreneurial Firm** | **Entrepreneurial Resource** | **Entrepreneurial Social Network** |
| Entrepreneurial firm can be explained as a hybrid form of economic organization combining selective advantages of market and hierarchy [20]. The entrepreneur has cognition and acts within target areas to reduce transaction costs while maximizing profits, but staying in line with visions for success [21]. | Entrepreneurial resources shape the environment by introducing new products, technologies, and administrative techniques into the firm, seizing new opportunities in the environment and taking preemptive action in response to perceived opportunity [27] [28]. Entrepreneur’s ability to exploit opportunities for new ideas and processes is shown to have significant impacts on performance [29] [30] [31]. | Access to a social network enables an understanding of the entrepreneurial landscape and identification of resources and information [37] [38]. Entrepreneurial abilities to initiate, maintain, and utilize relationships with various external social partners comprise coordination, relational skills, market knowledge, and internal communication [39]. Entrepreneur’s social ability to develop and use inter-firm relationships, measured by task execution and qualifications, determines firm’s success [40]. |

small start-up firms but is also applicable to corporate ventures by established firms [41]. An entrepreneurial firm thus engages in product-market innovations, undertakes somewhat risky ventures, and initiates proactive innovations to gain competitive edge [42]. Similarly, the well-studied concept of corporate entrepreneurship refers to the
development of new business ideas and opportunities within corporations [27]. This broad definition encompasses at least four schools of thought, each with its own assumptions and objectives: corporate venturing, intrapreneurship, entrepreneurial transformation, and “bringing the market inside.”

**Corporate venturing** pertains to the organizational arrangements that new ventures need and the processes associated with aligning them with the firm’s existing activities [43]. **Intrapreneurship** examines the often subversive tactics these corporate entrepreneurs adopt, as well as the actions executives take to make their lives easier or harder. It also considers the personalities and styles of individuals who make good corporate entrepreneurs [44]. **Entrepreneurial transformation** assumes that firms can and should adapt to an ever-changing environment and suggests that such adaptation would best be achieved by manipulating the firm’s culture and organization systems in a more entrepreneurial manner [45]. Finally, **bringing the market inside** focuses on structural changes to encourage entrepreneurial behavior, using the metaphor of the marketplace to suggest how firms should manage their resource allocations. It proposes the greater use of these market techniques as spin-offs and corporate venture capital operations.

Entrepreneurial SCM competences provide substantial advantages that facilitate SCM activities. As resources, they lead to superior performance, particularly in highly competitive or challenging environments. The most useful competences are those that are rare, valuable and inimitable because they are key determinant of superior organizational performance [46]. The RBV identifies inimitability and immobility as the other characteristics that support sustainable competitive edge, and intangible resources are important for gaining competitive edge in international settings [47]. As a bundle of business culture and processes, entrepreneurial SCM competence should provide a source of competitive edge because it is difficult for competitors to replicate. It is embedded in organizational processes and thus difficult for outsiders to observe [48]. Furthermore, entrepreneurial SCM competence is less likely to be perfectly mobile across organizations. It develops over time within the firm and is not easily transferred. Consistent with the RBV, we expect entrepreneurial SCM competence to offer the firm a key source of sustainable competitive edge. For resource-constrained manufacturing SMEs, entrepreneurial SCM competence is particularly important because it allows them to compete successful against large corporations.

**HYPOTHESES DEVELOPMENT**

**Recognizing Entrepreneurial SCM Competence**

We used a two-phase research design to conduct this study. In the first phase, we utilized an exploratory research approach in which we reviewed the relevant literature and interviewed several SME executives to learn their SCM strategies and to uncover key SCM constructs. In the second phase, we surveyed a large sample of automotive original equipment manufacturer (OEM) suppliers from five Association of Southeast Asia Nations (ASEAN) countries.

Manufacturing SMEs rarely fit the traditional profile of big, well-established firms with substantial financial and tangible resources. Rather, SMEs possess far fewer tangible assets, such as plants, property, and equipment, and lack financial and human resources. The control of vast resources favors large manufacturing firms to compete effectively in the supply chain. However, this implies that the complexities of supply chain operations are especially challenging for SMEs [49]. For SMEs, competing in the supply chain is an innovative act that requires them to possess processes that are unique and inimitable by the better resourced large firms.

The interviews with SME executives revealed several types of competences that appear critical to the performance of firms in a supply chain. Most of the interviewees mentioned the value of an entrepreneurial orientation, particularly during the expansion phase of their business. They also highlighted the importance of developing good relationships with both customers and suppliers in the supply chain. They further stressed that success required substantial coordination capability to pursue information alignment with supply chain members. Finally, these managers emphasized the significance of awareness to customers and markets, as facilitated by efforts to understand the customers and respond to their particular needs.

An inclusive review of the interviews indicates that the most important organizational attributes can be grouped into five categories: innovation orientation, risk-taking characteristics, proactiveness orientation, relational capital skill, and coordination capability. Our literature review supports that these attributes are vital to the performance of entrepreneurial firms. Hence, we define entrepreneurial SCM competence as the inimitable SCM capability for recognizing and pursuing business opportunities that engender success and growth. In theory, it is a second-order construct that is measured by first-order factors, as we summarized in Figure 1.

The five factors do not “cause” competitive advantage; rather, they collectively reveal the latent, intangible construct of entrepreneurial SCM competence. Other indicators are plausible, but we focus on the five factors that emerged from our interviews, and to some extent supported by our literature review. In developing our hypotheses, we further examined the extant literature to uncover potential antecedents of performance for SMEs participating in supply chain activities [11]. While the factors are relevant to any supply chain member, our exploratory investigation suggests that they are particularly important to the operations of manufacturing SMEs because they are generally
rare, valuable, inimitable, and are capable of creating superior performance.

Conceptualizing Entrepreneurial SCM Competence

We conceptualize entrepreneurial SCM competence as a multidimensional concept that reflects the extent to which firms adopt a bundle of SCM competences to compete in a supply chain. The concept also implies that the SME possesses intangible capabilities and processes that account for its SCM success, which eventually leads to superior performance. The competences span multiple dimensions, including learning about supply chain environments and adapting the organization to new supply chain channels through interactions with customers and suppliers.

Innovation Orientation: In the interviews, most of the SME managers mentioned the importance of an innovative approach. Firms with a strong innovative orientation tend to possess distinctive competences and outlooks [50], and are characterized by a managerial vision and innovative organizational culture that aims at achieving the firm’s goals through a supply chain [29]. These SME managers revealed that an innovation orientation implies active exploration of new businesses through the supply chain. Firms with limited tangible resources that want to pursue SCM strategies may need a strong innovative posture to take the initiative to pursue new opportunities in complex and risky markets. An innovation orientation also should give rise to processes, practices, and decision-making activities associated with supply chain activities and thus may contribute to firm performance [7].

Risk-Taking Characteristics: The critical role of risk-taking characteristics appears in virtually all SME literature. Risk-taking activities engender superior organizational performance for entrepreneurial firms. Firms in complex supply chains require seamless coordinated flows of goods, services, information, and cash; or else, they face significant supply risk [51]. Manuj and Mentzer [52] identify eight types of SCM risk: supply, operational, demand, security, macro, policy, competitive, and resource. Manufacturing SMEs with risk-taking entrepreneurial characteristics are likely to seek profit-maximizing strategies in which they leverage SCM.

Risk-taking or venturing behavior also may result when firms engage in new supply chains or provide new products and services to supply chain members.

Proactiveness Orientation: Most SMEs in our interviews are highly proactive with respect to their industry, product category, and how they compete in the supply chain. We define a proactiveness orientation as the firms’ tendency to originate proactive innovations that beat competitors to the punch [27]. Proactiveness entails a firm’s ability to integrate supply chain information and shape its environment by introducing new products, technologies, and administrative techniques [53]. This approach also involves seizing new opportunities in the environment and taking preemptive action in response to opportunities. A proactive firm seizes and exploits new opportunities [28]. Proactive behavior occurs when boundary spanners offer transparency to decision makers, which influences entrepreneurial and learning actions within the supply chain [54]. Thus, a proactiveness orientation drives entrepreneurial SCM competence.

Relational Capital Skill: In our interviews, SME executives frequently highlighted the importance of being socially connected to customer and suppliers, which the literature refers to as relational capital skill [55]. In this context, social networking activity is a strategy for augmenting their self-interests through mutual relationships. The benefit of information flows in such activities has been widely emphasized [56]. In SCM terms, a relational capital skill symbolizes an ability to connect with supply chain members who control necessary inputs, especially those whom the entrepreneurs know well enough to predict their behavior [57]. Through formal and informal communication channels, relational capital skill aids information sharing among supply chain members [58]. Moreover, relational activities in a supply chain, such as interactions with buyers and suppliers, facilitate the provision of firm-specific products and services, which may include creating awareness of the product, demonstrating its attributes, or modifying it to meet unique requirements. To accomplish this provision, manufacturing SMEs could engage in relationships with supply chain partners that leverage the core competencies of the individual partners and thereby better manage uncertainty in exchange processes [59]. In a supply chain, relational capital skill
represents not only how a firm interfaces with a particular partner but also how it connects with firms throughout the supply chain; hence, it should enhance manufacturing SMEs’ SCM competence.

Coordination Capability: Prior literature examined information sharing as an enabler of coordination capability within the supply chain [60]. Sharing information about labor and material costs, suppliers, distributors, and other market conditions is vital for manufacturing SMEs because it reveals the profitability of other supply chain members [61]. This competence refers to the capability to integrate key business processes among supply chain members to provide the correct products, services, and information [62]. A relationship also may arise between the use of coordination capability and the richness of shared information. Coordination capability among supply chain members has a positive and direct effect on both internal and external collaboration, and information sharing is a key dimension of collaboration. Coordination capability relates positively to systems integration, or the ability to use information sharing for collaborative purposes. Furthermore, information sharing between supply chain partners should be collaborative and enable partners to achieve the benefits of coordination capability [63]. Coordination capability simplifies manufacturing processes to increase cost efficiency, increases employees’ productivity, reduces variation, and eliminates waste. The possession of coordination capability signals to partner firms that information sharing can drive relationship development; hence, coordination capability is a factor that supports entrepreneurial SCM competence.

Entrepreneurial SCM Competence and SCM Strategies

As indicated in Figure 1, we postulate that entrepreneurial SCM competence reflects an SME’s capabilities to employ SCM effectively and it positively affects SCM strategies. An SME’s pool of competences dictates its strategies to fit the industry or market environment [64]. Besides, the relationship between entrepreneurship and strategic management has been verified [65]; thus, for resource-constrained manufacturing SMEs, entrepreneurial SCM competence is acutely important to the extent that they allow the firm to leverage its competency in the supply chain to develop quality- and efficiency-oriented strategies. Manufacturing SMEs attempt to achieve superior products that meet the preferences of industrial buyers well and reach buyers effectively and efficiency through SCM [6]. However, the competitive global market suggests that buyers are now better organized and more demanding. The extent of entrepreneurial SCM competence implementation differs by firm, though firms that are more advanced in their competence should use their resources more efficiently and effectively to achieve greater benefits. Hence, we hypothesize,

\[ H_2: \text{Entrepreneurial SCM competence positively affects the SMEs’ SCM strategies.} \]

SCM Strategies and Firm Performance

The ability of firms to succeed in competitive markets is largely a function of their internal capabilities and competences [47] [48]. Evolutionary economics theory elaborates on the superior ability of firms to develop particular organizational capabilities, which consist of critical competencies. Within a supply chain, SMEs attempt to offer products with value that buyers perceive as exceeding the value of alternative offerings. The urge to provide superior buyer value drives manufacturing SMEs to create and maintain a business culture that fosters the requisite business behaviors. Although operational practices typically emerge from the integration of unique knowledge of the firm [66], SCM strategies also reflect the quality- and efficiency-focused business activities in which a firm has become skilled [67]. Therefore, entrepreneurial SMEs are able to perform productive tasks repeatedly to create value in their SCM strategies [46], and in turn, the SCM strategies become the main source of the firm’s performance advantage [7]. Hence, we hypothesize,

\[ H_3: \text{SCM strategies positively affect SMEs’ performance.} \]

Entrepreneurial SCM Competence and Firm Performance

The RBV assumes that gaining and preserving a sustainable competitive advantage is a function of the resources that the firm brings to the competition and these resources provide the primary source of a firm’s success [48]. Research efforts have examined the relationship between resources and better-than-normal performance, stemming from the assertion that the heterogeneity of resources leads to variable competence and performance level [68]. Firms with valuable, inimitable, and non-substitutable resources generally excel in the market-place. Thus, competence and durable performance difference can be accounted for by asymmetric resource endowments across firms with differential competence [69]. Firms with an entrepreneurial advantage enjoy monopolistic edge to create resource position barriers [9]. The positive influence of entrepreneurship on firm market performance also has been empirically studied [57]. As product life cycles shrink rapidly in the modern supply chain environment, firms must rely on proprietary technology to bring high quality products to market quickly and efficiently ahead of the competition. To recap these ideas, we assert that entrepreneurial SCM competence, as evinced by innovation orientation, risk-taking characteristics, proactiveness orientation, relational capital skill, and coordination capability, positively affects manufacturing SMEs’ performance. Our literature review also suggests that the competency is especially salient for the performance of the manufacturing SMEs. Thus, we hypothesize,

\[ H_3: \text{Entrepreneurial SCM competence positively affects SMEs’ performance.} \]

METHODOLOGY

Questionnaire and Data Collection

To test the proposed model, we designated manufacturing SMEs as our sampling frame. Prior to conducting the survey, we first interviewed managers who had experience with SCM. We interviewed six experts (four practitioners, two academics)
to explore emergent phenomena and derive appropriate constructs and explanations, even as we uncovered key constructs and associated relationships. Conducting these interviews as a prelude to our survey-based research provides grounded and qualitative evidence about the validity of the key variables. We then undertook an exploratory study, beginning with an extensive literature review in which we located measurement scales and information for each construct. Insights and input from the interviews guided the survey instrument development. The resulting questionnaire used five-point Likert scales, and was administered according to well-established procedures. A group of business scholars reviewed the resulting questionnaire for face validity.

We collected data from automotive OEM suppliers in five ASEAN countries: Indonesia, Malaysia, the Philippines, Vietnam, and Thailand. We focused on this region in an attempt to expand existing literature, which largely has been confined to firms in the Western hemisphere. We conducted a series of one-day workshops in each ASEAN country, to which we invited representatives (i.e., production, purchasing, and quality assurance managers) from the tier suppliers of automobile SME manufacturers. The invitation, which came from the ASEAN Secretariat, informed participants about the “Proposed ASEAN Policy Blueprint for SME Development 2004–2014” and suggested methods ASEAN automotive manufacturers might use to enhance organizational capabilities. Participants also received self-assessment worksheets, which 165 of them completed and returned after the workshop. Response rates are 67.06%, 37.50%, 74.00%, 42.86%, and 32.00% in Vietnam, Thailand, the Philippines, Malaysia, and Indonesia, respectively. Most respondents (62.27%) worked for tier-1 suppliers, and almost half were employed by joint ventures or foreign direct invested firms. Majority of the respondents’ firms had some form of quality management system certification and implemented formal total quality management or similar continuous improvement programs.

**Measures**

To increase scale validity, we used multiple indicators to represent the unobservable constructs and employed existing scales whenever possible. The innovativeness orientation construct consists of six items that reflect the quality of the new product, in comparison with products developed in the focal company in the previous three years, competitors’ products, and other products developed by the firm [70]. Five items measure Risk-taking characteristics by asking respondents to indicate the extent to which their company’s attitudes toward uncertainty and risk [71]. To measure proactiveness orientation, we use five items that refer to the extent to which the company practices certain strategies to position itself in the market [72]. The seven items that measure relational capital show the extent to which the firm maintains relationships with its customers and suppliers [58] [73] [74]. For coordination capability, we use nine items that ask respondents to rate their firm’s practices on communication and information exchange with customers and suppliers [75] [76]. SCM strategies use nine items adapted from Hsu et al. [1], and the performance construct consists of four items commonly used in operations management literature (Table 2).

**Statistical Analysis**

To achieve a high degree of validity, we used multiple indicators to measure each latent construct. To assess the quality of the measures, we evaluated the psychometric properties of the survey instrument with confirmatory factor analysis (CFA) using LISREL 8.72; we provide the measurement scales in Table 2. In Table 3, we show the zero-order correlation matrix for the seven latent variables and provide a brief overview of their interrelationships. The correlation matrix shows that all correlations are statistically significant at $\alpha = .05$ and exhibit the expected positive relationships, in preliminary support for the relationships in Figure 1.

We verify the seven measurement models in Table 2 by examining all variables for normality using third- and fourth-order moments and reduced the skewness of the data. The LISREL 8.72 program also provides maximum likelihood estimates, with the covariance matrix as input. As Table 2 shows, the Cronbach’s $\alpha$ statistics for the constructs range from .855 for coordination capability to .894 for proactiveness orientation, which suggests that the scales are sufficiently reliable. Critics of Cronbach’s $\alpha$ argue that it is a simple measure of reliability based on internal consistency, but it fails to adequately estimate errors caused by the factors external to an instrument, such as differences in testing situations or respondents over time. For structural equation modeling, composite reliability (CR) and average variance extracted (AVE) are viable alternatives, because they are more parsimonious than Cronbach’s $\alpha$ [77]. Thus, in Table 2, we also provide the CR values, which range from .8995 to .9472, in excess of the recommended threshold value of .60. The AVE values range from .5377 to .8117, which exceed the recommended threshold level of .50. These three statistics in combination suggest that all the constructs are sufficiently reliable.

Next, we assessed the unidimensionality of each construct. We tested the measurement models for convergent validity (i.e., degree of association between measures of a construct), discriminant validity (i.e., degree to which measures of constructs are distinct), and nomological validity (i.e., validity of the entire model). In the CFA, each measure loads significantly on the expected constructs, which demonstrates convergent validity [77]. In Table 2, the seven constructs exhibit excellent convergent validity because their AVE is greater than .50. The test for discriminant validity examines the correlation between each pair of latent variables [78]. If the two latent variables are distinct, their correlation should be one-dimensional. In Table 3, all coefficients are significant and most are less than 0.5; thus, discriminant validity can be assumed. Nomological validity is assessed by the model fit indices. The analysis reveals that the measurement models are more than acceptable for reproducing the population covariance matrices. These results suggest an adequate level of construct validity.

Subsequently, we assessed the validity of entrepreneurial SCM competence as a second-order construct. In Table 4, innovativeness orientation (standardized loading $|\gamma| = .55, t = 7.68$), risk-taking characteristics ($\gamma = .71, t = 10.63$),
proactiveness orientation ($\gamma = .67, t = 9.73$), relational capital skill ($\gamma = .82, t = 11.09$), and coordination capability ($\gamma = .52, t = 7.25$) are all significant factors ($p < .01$) of the second-order construct; thus, suggesting a good level of convergent validity for entrepreneurial SCM competence. Furthermore, the CR of .8872 and AVE of .6178 indicate that entrepreneurial SCM competence as a second-order construct attains good construct validity. We proceed to estimate our theoretical structural equation model, with entrepreneurial SCM competence as a second-order construct and SCM strategies as a mediator.

In the theoretical model, we also tested the direct and indirect impacts of entrepreneurial SCM competence and the direct impact of SCM strategies on performance. In Table 5, we report the LISREL results, which show an excellent fit of the model to the data. Again, the first-order factors, innovation orientation ($\gamma = .60, t = 8.54$), risk-taking characteristics ($\gamma = .71, t = 10.70$), proactiveness orientation ($\gamma = .67, t = 9.73$), social capital ($\gamma = .81, t = 11.07$), and coordination capability ($\gamma = .53, t = 7.33$) all loaded significantly on entrepreneurial SCM competence ($p < .01$). With regard to the model parameter estimates, the results reveal that entrepreneurial SCM competence affects SCM strategies positively, with a coefficient of $\beta = .46 (t = 7.98$). These findings support H$_1$. Also, SCM strategies positively and significantly affect performance, with $\beta = .71 (t = 5.25$), in support of H$_2$. However, the impact of entrepreneurial SCM competence on performance is not statically significant at $\alpha = 5%$; hence, H$_3$ is not supported.

### Table 2

<table>
<thead>
<tr>
<th>Construct and Items</th>
<th>Standardized Loadings (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(A) Innovativeness Orientation</strong> (Cronbach’s $\alpha = .878$, CR = .8995, AVE = .6041)</td>
<td></td>
</tr>
<tr>
<td>The level of innovative and leading edge research &amp; development pursuits in your firm.</td>
<td>0.56</td>
</tr>
<tr>
<td>The level of novelty of the new products.</td>
<td>0.72</td>
</tr>
<tr>
<td>The use of the latest technological innovations in new product development.</td>
<td>0.66</td>
</tr>
<tr>
<td>The speed of new product development.</td>
<td>0.77</td>
</tr>
<tr>
<td>The number of new products the firm has introduced.</td>
<td>0.93</td>
</tr>
<tr>
<td>The number of new products that are first to market (early market entrants).</td>
<td>0.79</td>
</tr>
<tr>
<td>$t/df = 1.818, RMSEA = .054, NNFI = .99, AGFI = .94$</td>
<td></td>
</tr>
<tr>
<td><strong>(B) Risk-Taking Characteristics</strong> (Cronbach’s $\alpha = .881$, CR = .9219, AVE = .7034)</td>
<td></td>
</tr>
<tr>
<td>Senior executives share similar beliefs about the future direction of this organization.</td>
<td>0.68</td>
</tr>
<tr>
<td>Senior managers actively encourage change and implement a culture of improvement, learning, and innovation in moving toward excellence.</td>
<td>0.81</td>
</tr>
<tr>
<td>Employers have the opportunity to share in and are encouraged to help the organization implement change.</td>
<td>0.79</td>
</tr>
<tr>
<td>There is a high degree of unity of purpose throughout the company, without barriers between individuals and/or departments.</td>
<td>0.80</td>
</tr>
<tr>
<td>There is a comprehensive and structured planning process which regularly sets and reviews short and long-term goals.</td>
<td>0.74</td>
</tr>
<tr>
<td>$t/df = 1.818, RMSEA = .071, NNFI = .99, AGFI = .93$</td>
<td></td>
</tr>
<tr>
<td><strong>(C) Proactiveness Orientation</strong> (Cronbach’s $\alpha = .894$, CR = .9079, AVE = .6648)</td>
<td></td>
</tr>
<tr>
<td>Our company always stays on the leading edge of new technology in our industry.</td>
<td>0.73</td>
</tr>
<tr>
<td>We anticipate the full potential of new practices and technologies.</td>
<td>0.81</td>
</tr>
<tr>
<td>We proactively pursue long-range programs to acquire technological capabilities.</td>
<td>0.90</td>
</tr>
<tr>
<td>We constantly explore and attempt to acquire next generation technology.</td>
<td>0.80</td>
</tr>
<tr>
<td>Our research and development pursues truly innovative and leading edge research.</td>
<td>0.69</td>
</tr>
<tr>
<td>$t/df = 0.773, RMSEA = .000, NNFI = .100, AGFI = .97$</td>
<td></td>
</tr>
<tr>
<td><strong>(D) Relational Capital</strong> (Cronbach’s $\alpha = .874$, CR = .9032, AVE = .5748)</td>
<td></td>
</tr>
<tr>
<td>We actively and regularly seek customer inputs to identify their needs and expectations.</td>
<td>0.66</td>
</tr>
<tr>
<td>Customer needs and expectations are effectively disseminated and understood throughout the workforce.</td>
<td>0.72</td>
</tr>
<tr>
<td>We always maintain a close relationship with our customers and provide them an easy channel for communicating with us.</td>
<td>0.75</td>
</tr>
<tr>
<td>We have an effective process for resolving customers’ complaints.</td>
<td>0.71</td>
</tr>
<tr>
<td>We strive to establish long-term relationships with suppliers.</td>
<td>0.81</td>
</tr>
<tr>
<td>We use a supplier rating system to select our suppliers and monitor their performance.</td>
<td>0.70</td>
</tr>
<tr>
<td>Suppliers are actively involved in our new product, component, module, and system development process.</td>
<td>0.60</td>
</tr>
<tr>
<td>$t/df = 1.438, RMSEA = .052, NNFI = .99, AGFI = .93$</td>
<td></td>
</tr>
<tr>
<td><strong>(E) Coordination Capability</strong> (Cronbach’s $\alpha = .855$, CR = .9111, AVE = .5577)</td>
<td></td>
</tr>
<tr>
<td>Establishing more frequent contact with supply chain members.</td>
<td>0.61</td>
</tr>
<tr>
<td>Creating compatible information sharing systems with suppliers.</td>
<td>0.64</td>
</tr>
<tr>
<td>Locating closer to your customers.</td>
<td>0.47</td>
</tr>
<tr>
<td>Requiring suppliers to locate closer to your firm.</td>
<td>0.49</td>
</tr>
<tr>
<td>Outsourcing non-core activities to third-party logistics providers.</td>
<td>0.59</td>
</tr>
<tr>
<td>Improving the integration of activities across the supply chain.</td>
<td>0.72</td>
</tr>
<tr>
<td>Communicating your firm’s future plan to suppliers and customers.</td>
<td>0.78</td>
</tr>
<tr>
<td>Creating cross-organizational supply chain management teams.</td>
<td>0.72</td>
</tr>
<tr>
<td>Creating compatible information sharing systems with customers.</td>
<td>0.63</td>
</tr>
<tr>
<td>$t/df = 1.148, RMSEA = .030, NNFI = .100, AGFI = .93$</td>
<td></td>
</tr>
<tr>
<td><strong>(F) SCM Strategies</strong> (Cronbach’s $\alpha = .904$, CR = .9472, AVE = .6736)</td>
<td></td>
</tr>
<tr>
<td>Performance of your products.</td>
<td>0.54</td>
</tr>
<tr>
<td>Conformance of your products to specifications.</td>
<td>0.54</td>
</tr>
<tr>
<td>Durability of your products.</td>
<td>0.56</td>
</tr>
<tr>
<td>Flexibility and responsiveness of your delivery lead time.</td>
<td>0.66</td>
</tr>
<tr>
<td>Flexibility and responsiveness of your production lead time.</td>
<td>0.75</td>
</tr>
<tr>
<td>Turnovers of your raw materials and component parts.</td>
<td>0.81</td>
</tr>
<tr>
<td>Overall inventory turnovers.</td>
<td>0.77</td>
</tr>
<tr>
<td>Accuracy of inventory levels.</td>
<td>0.77</td>
</tr>
<tr>
<td>Delivery lead time of purchased materials and component parts.</td>
<td>0.70</td>
</tr>
<tr>
<td>$t/df = 1.336, RMSEA = .045, NNFI = .99, AGFI = .92$</td>
<td></td>
</tr>
<tr>
<td><strong>(G) Performance</strong> (Cronbach’s $\alpha = .923$, CR = .9449, AVE = .8117)</td>
<td></td>
</tr>
<tr>
<td>Sales Growth.</td>
<td>0.83</td>
</tr>
<tr>
<td>Market Growth.</td>
<td>0.83</td>
</tr>
<tr>
<td>Market Share.</td>
<td>0.96</td>
</tr>
<tr>
<td>Profitability.</td>
<td>0.80</td>
</tr>
<tr>
<td>$t/df = 2.22, RMSEA = .086, NNFI = .99, AGFI = .93$</td>
<td></td>
</tr>
</tbody>
</table>

Note: CR = composite reliability, AVE = average variance extracted.
Table 3
Correlation of the Constructs

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innovativeness orientation</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk-Taking characteristics</td>
<td>.362*</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proactiveness orientation</td>
<td>.489*</td>
<td>.441*</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relational capital</td>
<td>.385*</td>
<td>.581*</td>
<td>.514*</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coordination capability</td>
<td>.328*</td>
<td>.369*</td>
<td>.324*</td>
<td>.414*</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCM strategies</td>
<td>.483*</td>
<td>.391*</td>
<td>.355*</td>
<td>.429*</td>
<td>.322*</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Performance</td>
<td>.522*</td>
<td>.355*</td>
<td>.304*</td>
<td>.265*</td>
<td>.203*</td>
<td>.458*</td>
<td>1.000</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>.780</td>
<td>.786</td>
<td>.852</td>
<td>.736</td>
<td>.705</td>
<td>.594</td>
<td>.824</td>
</tr>
</tbody>
</table>

* All correlations are significant at α = 5% (two-tailed, n = 165).

Table 4
Second-Order Entrepreneurial SCM Competence Construct

Entrepreneurial SCM Competence

<table>
<thead>
<tr>
<th>Reliability Measures</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Composite Reliability</td>
<td>.8872</td>
</tr>
<tr>
<td>Average Variance Extracted</td>
<td>.6178</td>
</tr>
</tbody>
</table>

Second-Order Model Fit Indices

<table>
<thead>
<tr>
<th>χ² / degrees of freedom</th>
<th>1.36</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMSEA</td>
<td>.047</td>
</tr>
<tr>
<td>NNFI</td>
<td>.98</td>
</tr>
<tr>
<td>CFI</td>
<td>.98</td>
</tr>
<tr>
<td>IFI</td>
<td>.98</td>
</tr>
</tbody>
</table>

Table 5
Structural Equation Model Results

Entrepreneurial SCM Competence

<table>
<thead>
<tr>
<th>Structural Equation Model Fit Indices</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>χ² / degrees of freedom</td>
<td>1.39</td>
</tr>
<tr>
<td>RMSEA</td>
<td>0.49</td>
</tr>
<tr>
<td>NNFI</td>
<td>.97</td>
</tr>
<tr>
<td>CFI</td>
<td>.98</td>
</tr>
<tr>
<td>IFI</td>
<td>.98</td>
</tr>
</tbody>
</table>

** Statistically insignificant at α = 5%
H₁ and H₂ are supported, but H₃ is not supported
DISCUSSION

Our findings suggest that organizational capabilities of manufacturing SMEs support superior performance. Specifically, our results provide empirical evidence that manufacturing SMEs that possess a high level of entrepreneurial SCM competence perform better in their supply chains. Entrepreneurial SCM competence leads to superior SME performance through SCM strategies; that is, entrepreneurial SCM competence precedes SCM strategies, and SCM strategies affect manufacturing SMEs’ performance.

The results stress the importance of entrepreneurial SCM competence, which precedes SCM strategies in explaining performance, and indicate that SCM strategies should be viewed as means to achieve superior performance. Our findings support the notion that SCM strategies bridge the gap between entrepreneurial SCM competence and superior firm performance. The significant relationships from entrepreneurial SCM competence to SCM strategies, and then from SCM strategies to performance show that entrepreneurial SCM competence has indirect effects on firm performance. However, entrepreneurial SCM competence does not affect performance directly. This finding is significant in that it may provide an answer to the missing link between SMEs’ capabilities and performance. SMEs must implement appropriate SCM strategies to fully benefit from exceptional entrepreneurial SCM competence because such competence does not affect performance directly. The results also suggest that manufacturing SMEs can enhance their performance by establishing and skillfully managing their entrepreneurial SCM competence. These results in turn offer worthy theoretical and managerial implications.

MANAGERIAL IMPLICATIONS

Theoretically, our findings suggest that to flourish in this competitive global market, manufacturing SMEs should develop unique competence that are inimitable to maximize their utility in the supply chain. The possession of entrepreneurial SCM competence leads to the development of crucial organizational capability. Entrepreneurial SCM competence thus reflects superior firm resources, leading to superior SCM strategies undertaken by skilled personnel. As the RBV highlights, a firm’s foundational resources, including its key competency, are important in diverse business environments, because they provide a stable basis for developing specific competency, which is particularly useful to the extent that it is embedded in organizational culture and produce a unique configuration of resources.

Our results suggest that a firm’s entrepreneurial SCM competence is a multidimensional construct that taps specific internal competency. Although manufacturing SMEs tend to lack substantial financial and tangible resources, those that succeed in the competitive global market appear to leverage more fundamental, intangible resources, which constitute their entrepreneurial SCM competence. Their key intangible resources include innovation orientation, risk-taking characteristics, proactiveness orientation, relational capital skill, and coordination capability. Although undoubtedly other competencies are instrumental to manufacturing SMEs, our findings, based on interviews with practitioners and an intensive literature review, indicate that these five factors are particularly salient. As distinctive first-order constructs, they reveal the level of firms’ entrepreneurial SCM competence.

This study reveals that manufacturing SMEs’ performance hinges on the development and well-conceived manipulation of a particular SCM competency, which can be broken down into five unique capabilities as measured by the five first-order factors. Manufacturing SMEs may be relatively recent entrants into the supply chain. They also tend to lack the large base of financial and tangible resources that characterize large manufacturing firms. Their entrepreneurial SCM competence, as identified herein, helps them to overcome the scarcity of traditional resources and succeed through the supply chain. The quality of the management team in manufacturing SMEs also likely has particular relevance for firm survival. Various competencies possessed by management result from the specific circumstances, causal relationships, and unique social structure within each SME. Furthermore, entrepreneurial SCM competence may be relatively distinctive because it reflects the specialized approaches owned by individual managers or is embedded within the manufacturing SME. That is, entrepreneurial SCM competence comprises of a collection of firm-specific capabilities that are inimitable by would-be rival firms.

By exploring entrepreneurial SCM competence as a second-order construct, we provide managers with a means to assess their own abilities in their supply chain. Managers can examine how multiple constructs simultaneously form their firms’ entrepreneurial SCM competence. Also, the complex structure of entrepreneurial SCM competence makes it difficult for competitors to replicate this comprehensive strength. We highlight its components and empirically confirm their explanatory value. Managers of manufacturing SMEs should devise an appropriate collection of capabilities to support their entrepreneurial SCM competence.

This study provides number of limitation. First, though we identify five distinctive dimensions of entrepreneurial SCM competence, we acknowledge there are likely other relevant dimensions. Ongoing research should investigate these potential dimensions, such as the organizational learning or knowledge management in which SMEs engage after participating in supply chain activities. Second, our model does not consider performance from multiple perspectives. Third, the antecedents of entrepreneurial SCM competence have yet to be explored. Further research should investigate both internal and external factors of SMEs that influence entrepreneurial SCM competence.

ACKNOWLEDGEMENT

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A LONGITUDINAL STUDY OF THIRD PARTY LOGISTICS SERVICES

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ABSTRACT

This paper analyzes the scope of services offered by the third-party logistics providers in the United States from 2002 to 2010. The purpose of this study is to investigate the strategic service development in the third-party logistics industry. The results show broadened service offerings and industry coverage over the years. The service offerings differ among various asset ownerships, and global 3PLs offer more logistics, transportation, and special services.

Keywords: third party logistics services

INTRODUCTION

In order to remain competitive in today’s changing business environment, more and more companies focus on core competencies. As companies expand into the global marketplace, logistics becomes critical in support of the global supply chain. Inventory carrying cost, transportation, and warehousing are the largest components of the logistics bill in the United States (Wilson, 2004). Instead of developing in-house capabilities in the various logistics disciplines such as transportation planning, warehouse management, and information technology, companies are opting to outsource to third-party logistics (3PLs) providers. Those firms are able to concentrate on their own core business, while the 3PLs providers concentrate on inflows and outflows of the global supply chain activities. Boyson et al. (1999) showed that the outsourcing of logistics functions had proven to be effective in helping firms to achieve competitive advantages, improve their customer service levels and reduce their overall logistics costs. Berglund et al. (1999) found that 3PLs can add value by creating operational efficiencies and by sharing resources between customers.

Third-party logistics is the use of contracted firm(s) to supply services in the planning, implementation and controlling of the flow and storage of raw materials, in-process inventory, finished goods, and related information throughout the supply chain. They may handle all or part of the distribution of merchandise along the supply chain to the consumer. Third party logistics was identified as a separate industry and service in the late 1980s, and started to gain market share in the U.S. only since early 1990s (Ashenbaum, et al., 2005). However the 3PL industry has grown rapidly from about $6 billion in 1991 to $107.11 billion in year 2009. The growth rate is estimated to be steady at around 18% to 22% annually. The largest vertical industry-wide expenditures on 3PLs are from retailing, technology, and automotive industries (Armstrong report, 2010). In U.S. 3PLs account for 16% of total logistics spending in 2008 and 77% of Fortune 500 companies outsourced some portion of logistics function in 2008 (Coyle, et al., 2009). Lieb and Bentz’s study (2004) found out that the average 3PL user paid approximately one-third of the company’s logistics operating budget to 3PL providers in 2003.

3PL relationships are more complex than traditional logistics supplier relationships, which are often transaction based and focus on single function (Simchi-Levi, et al., 2009, p. 149). As 3PLs providers become more vital to a company’s operations, these arrangements require active participation by both parties. In contracting out the logistics operations, the third party provider is now a significant partner which has significant impacts on the company’s quality, service, and dependability. This paper investigates the strategic development of American 3PLs services in recent years and studies how 3PLs fulfill their roles in today’s global supply chains.

LITERATURE REVIEW

In earlier years, companies chose 3PL providers mainly by cost. However Millegan (2000) noted that more meaningful relationships had been emerging since late 1990s. Bhatnagar et al. (1999) found that other than cost, customer service, and flexibility (customization) were the most important factors for selecting logistic outsourcing. For example, shippers are now choosing their providers based on their emphasis on value, innovation and performance in an increasingly global context. This trend presents a problem for the provider. Millegan’s study (2000) indicated that customer demands for performance and sophistication had been accelerating; and in many ways, the 3PLs are not keeping pace.

Lieb and Bentz’s (2005) surveyed the use of 3PLs services by large American manufacturing firms. They found that eighty percent of sixty Fortune 500 manufacturers indicated that they had used 3PL services in 2004. Sixty percent of the users reported using multiple 3PL providers, reflecting the difficulty encountered by individual providers in meeting the broad service requirements of many large 3PL customers. According to a similar report by Armstrong & Associates, over eighty percent of Fortune 100 companies use 3PLs for logistics and supply chain functions. According to their report, General Motors and Wal-Mart each use over 30 third-party logistics service providers. Traditionally, turnover rate was high in 3PL market. Study shows that more than one-third of users have cancelled at least one 3PL contract (Mottley, 1998). However Lieb and Bentz’s survey (2004) showed seventy-two percent of the users identified in their survey had used 3PL services for more than five years, which is the highest percentage ever reported in this category in their surveys. This indicates that the relationships between customers and some 3PLs are stabilized over time and may be changing from adversary to partnership.
Various strategies are utilized by 3PL providers. Other than serving the needs of individual customer, some 3PLs take multiple customers within a particularly focused industry sector, yielding greater efficiencies and cost savings. Some 3PLs spend great resources to develop competitive specific channels and then use the channel throughout their customer base. Industry-specific 3PLs often use the same supply chain design and channels for clients that are competitors (Burnson, 1999).

Another strategy for 3PLs is to consolidate or form alliances with other 3PLs. As mentioned earlier, most of these 3PLs offer a variety of services from transportation management, contract carrier, warehouse management, and information technology, but no one company dominates the market share in all of these areas. Consolidation or multiple partner alliances are sometimes the only way to provide the range of diverse geographic services demanded by customers (Cook, 1998). Current trend in consolidation and strategic alliances comes from the pressure of 3PL users to extend global capabilities and provide one-stop-shopping. Cost efficiency can be improved as the benefit of scale. Some examples of consolidation include UPS’s acquisition of Fritz, which allowed freight forwarding to be added to the expertise of the transportation and warehousing giant. Fritz Companies were also significant ocean NVOCCs as well as charter agents. Thus UPS was able to move beyond the small parcel dimension of global trade. Exel, a warehousing and freight-forwarding leader, acquired Mark VII so that it could add domestic surface transportation management to its offered services. In addition to partnerships with other service providers, 3PL providers also enhance and expand partnerships with their users. Furthermore, as globalization escalates, the 3PL providers seek international partners for overseas coverage.

The other option for 3PL providers is to target a specialized niche market to differentiate them and then form alliances with other players. HUB Group is a good example of this strategy. Hub Group has decided to focus on intermodal transportation due to its strong relationship with the nation’s railroad services. When a niche player has a customer that is looking for a more comprehensive service, they may partner up with another niche player that complements their own service. HUB Group partnered up with TMM Logistics in Mexico in order to be able to increase their presence in Mexico. TMM Logistics is the dominant logistic provider in Mexico. With this strategic partnership Hub, a niche 3PL player, is able to provide cross-border transportation.

Most of the extant literature focuses on the perspectives from the customers/users of 3PL services. For example, Murphy and Poist (1998) examined third-party logistics usage among a group of small to large manufacturers and non-manufacturers. Vaidyanathan (2005) proposed a conceptual framework using IT as the focus to evaluate the core functionalities of 3PL providers for the users. Moberg and Speh (2004) surveyed the warehouse customers to compare the selection criteria of a regional warehouse and a national warehouse. Some literature study 3PLs within a specific country context. For example, Lieb and Bentz (2004, 2005) and Langley et al. (2004) repeatedly surveyed the use of 3PL services among large American manufacturers over the years. Separate studies by Pipilani et al. (2004) and Wilding and Juriado (2004) investigated customers’ perceptions of 3PLs in Singapore and Europe, respectively.

Murphy and Poist (2000) compared the perspectives of 3PL providers and 3PL users on most commonly provided/used service. They found some overlap and mismatch between the 3PL services offered and used. There are overlaps on five of the ten most commonly provided/used services: EDI capability, freight consolidation, warehousing, consulting, and freight bill payment. The customers tend to be interested in operational services such as customs clearance, pick and delivery, freight charge auditing, intermodal service, and order picking and packing. However, their sample size was rather small—thirty-seven 3PL providers and sixty-eight 3PL users and the comparisons are not from paired samples.

There is very little research from the perspective of the 3PL service provider. Hertz and Alfredsson (2003) followed the strategic development of four different types of logistics firms into 3PLs. They found that the existing network of these firms’ customers, customers’ customers and partners seemed to have played an important role for the development into a 3PL and also in the continued development. Larson and Gammelgaard (2001) studied Danish logistics providers and found them to be more niche firms, focusing on the domestic market and limited sets of customers by industry. Lieb and Kendrick (2003) provided some macro level insights into the third-party logistics industry; but their results were based on a survey of a small sample of twenty CEOs of the largest 3PL companies in the U.S.

**RESEARCH QUESTIONS AND HYPOTHESES**

This research explores service offerings of one hundred 3PL providers in the United States for four years to investigate how 3PL service scope has been strategically developed in response to the customers’ growing needs in global supply chain management. As more diverse industries use 3PLs and outsource more logistic functions, the scope of services provided by 3PLs shall be broadened. Hence the following hypotheses are proposed.

**H1:** The scope of services provided by the third-party logistics providers gets broader over time.

**H2:** 3PLs serve more industry types over time.

**H3:** 3PLs serve more global region over time.

**H4:** Asset ownership of 3PL does not change over time.

**H5:** 3PL services vary among asset ownership.

**H6:** The scope of services differs between global 3PLs and domestic 3PLs.
METHODOLOGY

This research uses secondary data published by Inbound Logistics on their annual survey of one hundred American 3PLs from 2002 to 2010. Unlike Lieb and Bentz’s survey (2003), which contains CEOs’ comments from only the largest twenty 3PLs in U.S., this survey data consist of a mix of large, public companies and small, niche providers. This database includes information such as regions and industry sectors served by 3PLs, asset or non-asset based ownership, services in six categories, and membership in ISO certification, SmartWay, and C-TPAT.

Table 1 provides a list of these six categories and their specific services. Services listed on this database were much broader in scope and in industry coverage comparing to the ones listed on Lieb and Bentz’s (2005) survey. Their survey contained only 26 services for sixty large manufacturing companies.

Table 1: Major 3PL services categories

<table>
<thead>
<tr>
<th>Category</th>
<th>Service Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logistics Services</td>
<td>Inbound Logistics, Integrated Logistics, Warehousing, Lead Logistic Provider, Inventory Management, JIT, Process Re-Engineering, Vendor Management, Payment Audit Processing, Product Life Cycle Management, Global Trade Services</td>
</tr>
<tr>
<td>Transportation Services</td>
<td>Small Package, Air Cargo, LTL, TL, Intermodal, Ocean, Rail, Bulk, Dedicated Contract Carriage, Fleet Acquisition, Equipment/Drivers, Final Mile</td>
</tr>
<tr>
<td>Warehousing Services</td>
<td>Pick/Pack Sub-Assembly, Cross docking, DC Management, Location Services, Vendor Managed Inventory, Fulfillment</td>
</tr>
<tr>
<td>Special Services</td>
<td>Direct to Store, Direct to Home, Import/Export/Customs, Reverse Logistics, Marketing Customer Service, Logistics/Transportation Consulting, Global Expansion (sourcing/selling), Security Analysis, Contingency/Crisis Planning, Labor Management</td>
</tr>
<tr>
<td>Technology/ Web Services</td>
<td>EDI, Satellite/Wireless Communication, Enterprise Web Enablement, Product Visibility, Customer Relationship Management</td>
</tr>
</tbody>
</table>

Source: Inbound Logistics, various issues 2002-2010

Radar diagrams are drawn to show the levels of the five service categories over the years. ANOVA tests are conducted to analyze service category and industry breadth over years as well as the asset ownership impact on service categories. Chi-square tests are conducted to show changes on region served and asset ownership over years. Independent t test is done to see the regional impact on service offerings. In addition, nonparametric Spearman’s corrections are calculated to see the relationships between service category and industry.

ANALYSIS RESULTS

There are six strategic service categories provided by 3PLs—logistics, transportation, warehousing, special service, technology and internet-based services. Each category contains four to twelve specific services for a maximum of 48 possible services. Figure 1 shows the percentages of the aggregated counts and Figure 2 show the percentage of specific service offered by 3PLs from 2002 to 2010. Over the years, higher percentages of 3PL services are offered, especially on technology/web related services such as enterprise web enablement, product visibility, etc. For logistics services, the most commonly offered services are inbound logistics and integrated logistics, but only about 50% of them offer global trade service and product life cycle management. For transportation services, TL, LTL, and intermodal are offered by almost all 3PLs. New services such as bulk and final mile are growing in recent years. For warehousing services, over 80% of the companies offer cross docking and pick/pack subassembly and more companies offer vendor managed inventory and location services in recent years.

Special service and technology related service are the two categories that show many changes over the years. Logistics/transportation consulting was offered by 40% of the companies in 2002, but in 2010 that number increased to 93%. Reverse logistics was offered by 78% of the companies in 2002 and 93% of the companies in 2010. Deliver directly to store service was offered by 69% in 2002 and 86% in 2010. New services such as global sourcing and market expansion, security analysis, contingency & crisis planning, and logistics labor management were added to the list in 2007. On the technology side, EDI link has been offered by almost all 3PLs since 2002. However, all other technology related services are growing rapidly. For examples, enterprise web enablement service was increased from 52% in 2002 to 92% in 2010, while product visibility service was increased from 39% in 2002 to 96% in 2010. These results, in general, are consistent with the trend findings from Persson and Virum (2001) and Lieb and Bentz (2003).

ANOVA analysis (Table 2) on the aggregated numbers of total services show significant growth at p=0.000 level. Hence Hypothesis 1 is supported. Further analyses on each service category find that transportation service, special services, and technology based service show significant growth over the years, with p values of .028, .001, and .000, respectively. The technology related services show double digit growth in most of the years. Although not at the significant level, logistics services are also growing at a steady rate. The service categories that have more future growth potentials are in the transportation and special service areas.

Four industry sectors—manufacturing, retail/e-tail, distributor, and services—are reported in the survey. Most 3PLs serve more than one industry sector. Table 2 also shows that 3PLs are serving more industries over time at significant level of .000. Hence hypothesis 2 is supported. Further analyses on each industry sector reveal that all growth comes from the retail sector, distribution sector, and service sector, with p values .006, .018, and .001, respectively. Manufacturing sector is already saturated, and service section still has room to grow.

(Insert Table 2 here.)
As the supply chains getting global, one would expect the 3PLs will also expand their services to global regions. However Chi-square test (Table 3) does not show significant difference over the years. Hence Hypothesis 3 is rejected. However there is a noticeable increase on global region in 2010. The database provided more detailed region breakdown data in 2010. While all 3PLs serve North America region, 58% serve Asia/SouthEast Asia/India, 57% serve Europe/Eastern Europe/Russia, 54% serve South America, and 48% serve Middle East/North Africa.

Table 3 shows significant changes on asset ownership of 3PLs over the years. The p-value is at .033, hence Hypothesis 4 is rejected. According to the surveyed companies, pure asset-owned 3PLs are going down from 23% in 2002 to only 6% in 2010, while non-asset owned 3PLs grow from 44% in 2002 to 50% in 2010 and the number of 3PLs leverage both asset and non-asset capabilities grows from 32% in 2002 to 44% in 2010.

(Insert Table 3 here.)

Asset ownership varies among the 3PL companies. In general asset-based providers offer dedicated services, primarily through owned or leased assets. Non-asset-based providers offer administrative management services, and tend to subcontract for the necessary logistics assets which are not available in-house. ANOVA tests are conducted on the four years data and find significant difference (p=.000) in the total service levels among the three types of asset ownership. Non-asset based 3PLs offer an average of 69.42% of all service surveyed. Asset based 3PLs offer an average of 66.07% of all services and the both non-asset and asset based 3PLs offer an average of 75.7% of all services. Hence Hypothesis 5 is supported. In fact 3PLs that leverage on both non-asset and asset based capabilities provide more service in all service categories, the averages ranging from 68.01% in special service to 81.89% in logistics. They also serve more industry section, but the difference is not significant. This result is consistent with Stank and Maltz’s study (1996), but it is different from Murphy and Poist’s study (1998). Murphy and Poist conclude that there are no differences in the number of services offered by either asset-based or non-asset-based providers. However, their study compares customers’ reported usage of services from asset-based and non-asset-based providers, not the actual services offered by 3PLs.

(Insert Table 4 here.)

Table 3 shows no significant difference in regions served by 3PLs over the years. However Table 5 indicates that the level of services differs between the global players and domestic players significantly (p=.000). Hence Hypothesis 6 is supported. Global 3PLs provide significant broader level of services in all categories except the technology category. They also serve more industry sectors (all p values=.000).

(Insert Table 5 here.)

IMPLICATIONS AND CONCLUSION

Using services profiles gathered from one hundred American 3PLs from 2002 to 2010, analyses are conducted to provide a comprehensive study on the strategic development in this industry. Six hypotheses are proposed based on extant literature. Hypothesis 1 anticipates broader service scope over the years. Out of the six service categories, two categories—logistical services and warehouse services—seem to reach maturity. This is consistent with Van Hoek’s (2000) findings that traditional third-party logistics services such as warehousing and logistics have become commoditized. Hence the growth of overall service offerings have come from transportation services, special services, technology related services. As the complexity and size increase with global business, the customers have demanded more service offerings in order to organize and structure their supply chains and logistics. The growth of the third-party logistics industry makes both the formation and dismantling of supply chain arrangement easier. This offers the opportunity for supply chain participants to concentrate on their core capabilities.

Hypothesis 2 proposes that more industry sectors are served by 3PLs over the years. Both hypotheses are supported by this study. Third-party logistics are most popular in manufacturing sectors. However, this research find that industry sectors such as retail and e-tail, distribution and wholesale, and service are more important than manufacturing sectors in expanding 3PL service scope.

Asset based companies are typically larger firms. They usually enjoy economies of scale, own warehouse or transportation assets, have broader industry knowledge, and have a larger customer base. However non-asset based firms are more flexible and more able to tailor services with specialized industry expertise. This study finds that there are fewer pure asset based 3PLs over the years. Asset-based companies are tapped into the non-asset based capabilities to serve their customers. They have been expanding the service scope to satisfy customer’s desire for “one-stop” shopping.

According to Lieb’s 2003 user survey, users of 3PLs generally did not see 3PL providers as leading edge suppliers of information technology. Lieb and Bentz (2004) indicated that 3PLs must decide upon appropriate strategies for strengthening their technology capabilities to convince potential users. This research shows that 3PLs have been consistently and significantly improved their technology and web service offerings since 2004. Special services such as logistics and transportation consulting, reverse logistics, and delivery to store are now commonly offered, and new services like delivery directly to home and import/export service and custom clearances are gaining ground. In 2007 novel services on global sourcing, contingency planning for crisis, logistics labor management are offered. In 2010 security analysis are listed the first time and 35% of the companies has offered this service. These new capabilities will strengthen the strategic position of this industry.

Y. Helio Yang
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Table 2: ANOVA tests on service category and industry served by year

<table>
<thead>
<tr>
<th>Service Category</th>
<th>2002</th>
<th>2004</th>
<th>2007</th>
<th>2010</th>
<th>(F) Statistic</th>
<th>Sig. 02_04 % Growth</th>
<th>04_07 % Growth</th>
<th>07_10 % Growth</th>
<th>Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total services</td>
<td>63.54</td>
<td>74.02</td>
<td>73.11</td>
<td>74.36</td>
<td>9.567</td>
<td>.000</td>
<td>16.5%</td>
<td>-1.2%</td>
<td>1.7%</td>
</tr>
<tr>
<td>Logistics services</td>
<td>71.81</td>
<td>73.55</td>
<td>75.56</td>
<td>76.46</td>
<td>0.923</td>
<td>.482</td>
<td>2.4%</td>
<td>2.7%</td>
<td>1.2%</td>
</tr>
<tr>
<td>Transportation services</td>
<td>62.53</td>
<td>70.34</td>
<td>70.98</td>
<td>69.44</td>
<td>3.071</td>
<td>.028</td>
<td>12.5%</td>
<td>0.9%</td>
<td>-2.2%</td>
</tr>
<tr>
<td>Warehouse services</td>
<td>69.53</td>
<td>76.43</td>
<td>76.43</td>
<td>77.10</td>
<td>1.270</td>
<td>.284</td>
<td>9.9%</td>
<td>0.0%</td>
<td>0.9%</td>
</tr>
<tr>
<td>Special services</td>
<td>55.72</td>
<td>69.70</td>
<td>60.49</td>
<td>64.14</td>
<td>5.792</td>
<td>.001</td>
<td>25.1%</td>
<td>-13.2%</td>
<td>6.0%</td>
</tr>
<tr>
<td>Tech/Web services</td>
<td>53.54</td>
<td>74.34</td>
<td>82.42</td>
<td>87.27</td>
<td>48.768</td>
<td>.000</td>
<td>38.8%</td>
<td>10.9%</td>
<td>5.9%</td>
</tr>
</tbody>
</table>

Table 3: Chi-square tests on region and asset ownership by year

<table>
<thead>
<tr>
<th>Region</th>
<th>Non-Asset</th>
<th>Asset</th>
<th>Both</th>
<th>2002</th>
<th>2004</th>
<th>2007</th>
<th>2010</th>
<th>Chi-Square</th>
<th>Sig.</th>
<th>02_04 % Changed</th>
<th>04_07 % Changed</th>
<th>07_10 % Changed</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>42</td>
<td>51</td>
<td>46</td>
<td>40</td>
<td>2.862</td>
<td>13</td>
<td>21.4%</td>
<td>-15.5%</td>
<td>.00</td>
<td>11.4%</td>
<td>2.0%</td>
<td>-13.0%</td>
<td>11.1%</td>
</tr>
<tr>
<td>Global</td>
<td>58</td>
<td>49</td>
<td>54</td>
<td>60</td>
<td>3.418</td>
<td>.034</td>
<td>15.8%</td>
<td>5.9%</td>
<td>.00</td>
<td>5.6%</td>
<td>15.8%</td>
<td>2.0%</td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Service category means and ANOVA tests by asset ownership

<table>
<thead>
<tr>
<th>Service Category</th>
<th>Non-Asset</th>
<th>Asset Based</th>
<th>Both non-asset</th>
<th>(F) Statistic</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total services</td>
<td>69.4236</td>
<td>66.0768</td>
<td>66.4909</td>
<td>9.199</td>
<td>.00</td>
</tr>
<tr>
<td>Industry served</td>
<td>85.7713</td>
<td>81.0484</td>
<td>87.3333</td>
<td>1.887</td>
<td>.153</td>
</tr>
<tr>
<td>Logistics services</td>
<td>73.8691</td>
<td>64.4144</td>
<td>78.1884</td>
<td>9.681</td>
<td>.00</td>
</tr>
<tr>
<td>Transportation services</td>
<td>67.9532</td>
<td>58.8105</td>
<td>72.1525</td>
<td>7.863</td>
<td>.000</td>
</tr>
<tr>
<td>Warehouse services</td>
<td>66.4889</td>
<td>83.0639</td>
<td>81.8886</td>
<td>13.001</td>
<td>.000</td>
</tr>
<tr>
<td>Special services</td>
<td>59.2672</td>
<td>57.7061</td>
<td>68.0149</td>
<td>6.495</td>
<td>.002</td>
</tr>
<tr>
<td>Tech/Web services</td>
<td>71.8085</td>
<td>71.6129</td>
<td>78.5333</td>
<td>3.418</td>
<td>.034</td>
</tr>
</tbody>
</table>

Table 5: Service category means and independent t tests by region served

<table>
<thead>
<tr>
<th>Service Category</th>
<th>Domestic</th>
<th>Global</th>
<th>t Value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total services</td>
<td>67.01458</td>
<td>74.69697</td>
<td>-4.536</td>
<td>.00</td>
</tr>
<tr>
<td>Industry served</td>
<td>83.93855</td>
<td>86.99095</td>
<td>-1.412</td>
<td>.159</td>
</tr>
<tr>
<td>Logistics services</td>
<td>68.00972</td>
<td>78.89412</td>
<td>-5.166</td>
<td>.000</td>
</tr>
<tr>
<td>Transportation services</td>
<td>61.79598</td>
<td>73.22557</td>
<td>-5.115</td>
<td>.000</td>
</tr>
<tr>
<td>Warehouse services</td>
<td>74.48777</td>
<td>75.11244</td>
<td>-.195</td>
<td>.845</td>
</tr>
<tr>
<td>Special services</td>
<td>57.20654</td>
<td>66.4357</td>
<td>-3.722</td>
<td>.000</td>
</tr>
<tr>
<td>Tech/Web services</td>
<td>74.52514</td>
<td>74.11765</td>
<td>.160</td>
<td>.873</td>
</tr>
</tbody>
</table>

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INSIGHT AND EMERGING CHALLENGES ON JAPAN’S INFORMATION AND COMMUNICATION TECHNOLOGY SECTOR

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ABSTRACT

The more science and technology has advanced, the more of research and development have been active in businesses, and businesses have been benefited from their outcome. Not only businesses enjoy the outcome on their own, but they also export the outcome to cross-borders, so called technology trade. Japan generated 1.63 trillion Yen excess of export out of technology trade in 2008. The export has sustained the Japan’s economy. This paper explores the insight of Japan’s technology trade, points out a remarkable excess of technology import in ICT sector, and describes Japan’s challenges for establishing technology competitiveness in ICT sector.

Keywords: ICT, information and communication technology, technology trade, technical know-how

INTRODUCTION

According to Ministry of Internal Affairs and Communication, the technology trade is defined as providing (exporting) and receiving (importing) patents, utility models, technical know-how result from research and development efforts in science and technology to cross-borders. They are traded internationally in the form of transfer of rights, approval of utilization, and others. It also reported in its Johotsushin Hakusho 2010 that Japan has generated 1.63 trillion Yen excess of export out of technology trade in total of all industry sectors with 2.23 trillion Yen of export and 600 billion of import in 2008.

It could be recognized that Japan has taken advantage of its competitiveness in technology trade and generated larger volume of export than import. However, there is another remarkable finding in terms of Japan’s import out of technology trade. As Figure-1 shows, there is a distinctive nature in Japan’s import out of technology trade that Information and Communication sector shares 56.0% of total technology import in 2008. The data highlights a Japan’s remarkable dependence on technology import in ICT (Information and Communication Technology) sector.

JAPAN’S ICT SECTOR

Japan has enjoyed its competitiveness in technology especially in manufacturing sector such as automobile industry. According to Kagaku Gijutsu Hakusho 2007 issued by Ministry of Education, Culture, Sports, Science and Technology-Japan, the automobile sector generated excess of export about 1.12 trillion Yen out of technology trade in 2005 shown in Table-1.

While generating its technology competitiveness in manufacturing sector, however; Japan has been facing challenges in developing ICT sector competitiveness. Actually, Ministry of Internal Affairs and Communication pointed out the investment for enhancing information accessibility as one of key challenges for Japan’s revival. Although Japan has developed an advanced information and communication infrastructure, it is still in behind in terms of capturing the competitiveness in ICT sector.

< Figure-1: Technology Import by Industry Sector in 2008 >

(Source: Johotsushin Hakusho 2010, Ministry of Internal Affairs and Communication: Translated in English)
Figure 2 is the result of ICT ranking evaluation conducted by Ministry of Internal Affairs and Communication. The evaluation was developed in terms of 12 indices in 1) user charges, 2) speed, 3) security, 4) mobility, 5) dissemination, 6) infrastructure element. The overall evaluation rankings were developed by calculating the mean deviations for each index for each country. While it is evaluated that Japan has advanced ICT infrastructure, the ICT competitiveness has been lost since 2004 shown in Figure 3.

As government has promoted e-Japan Strategy in 2001 and 2003, the ICT infrastructure has successfully been advanced, however, it became clear that the utilization of the ICT infrastructure remains low. Thus, policy priority was shifted to enhance the utilization of advanced ICT infrastructure to form the competitiveness in ICT sector, and in order to actualize it, the investment for enhancing information accessibility became the key factor.

Table 1: Japan’s Technology Export / Import in Automobile Sector in 2005

<table>
<thead>
<tr>
<th>Counterpart Countries</th>
<th>Export</th>
<th>Import</th>
<th>Export - Import</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.</td>
<td>5,798</td>
<td>70</td>
<td>5,728</td>
</tr>
<tr>
<td>Thailand</td>
<td>991</td>
<td>0</td>
<td>991</td>
</tr>
<tr>
<td>U.K.</td>
<td>558</td>
<td>11</td>
<td>547</td>
</tr>
<tr>
<td>China</td>
<td>393</td>
<td>0</td>
<td>393</td>
</tr>
<tr>
<td>Indonesia</td>
<td>371</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>India</td>
<td>232</td>
<td>0</td>
<td>232</td>
</tr>
<tr>
<td>Australia</td>
<td>217</td>
<td>0</td>
<td>217</td>
</tr>
<tr>
<td>Taiwan</td>
<td>178</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>South Korea</td>
<td>58</td>
<td>2</td>
<td>56</td>
</tr>
<tr>
<td>Others</td>
<td>2,549</td>
<td>45</td>
<td>2,504</td>
</tr>
<tr>
<td>Total</td>
<td>11,286</td>
<td>128</td>
<td>11,157</td>
</tr>
</tbody>
</table>

(Source: Kagaku Gijutsu Hakusho 2007, Ministry of Education, Culture, Sports, Science and Technology-Japan: Translated in English)
< Figure-3 Changes in ICT Competitiveness Ranking >

(Source: Johotsushin Hakusho 2009, Ministry of Internal Affairs and Communication: Translated in English)

< Figure-4 International Comparison of Growth in Information Capital (for the entire industry) >

(expressed as an index with the figure for 1995 as 100)

(Source: Johotsushin Hakusho 2009, Ministry of Internal Affairs and Communication: Translated in English)
< Figure-5 International Comparison of Growth in Information Capital (Wholesale/Retail/Transportation Industry) >

(Source: Johotsushin Hakusho 2009, Ministry of Internal Affairs and Communication: Translated in English)

< Figure-6 International Comparison of Growth in Information Capital (Education/Healthcare/Other public service) >

(Source: Johotsushin Hakusho 2009, Ministry of Internal Affairs and Communication: Translated in English)
JAPAN’S INFORMATION CAPITAL

Information capital includes tangible and intangible asset consisting of databases, information systems, networks, and technology infrastructure. This information capital could be divided into two major category, hardware infrastructure and software applications [5]. Japan’s information capital, especially software applications through which information and knowledge are obtained, has not successfully grown since 1995. The installation and accumulation of application software has not been successful in Japan. As Figure-4 shows, it has the lowest growth among the counterpart developed countries in the world. Although the figure is a comparison with entire industry, the same phenomenon remains when you look into each industry. The Figure-5 and Figure-6 show the growth in information capital in wholesale/retail/transportation industry and education/healthcare/other public service industry respectively as examples. It shows the less growth phenomenon same as entire industry. There is a remarkable gap between Japan and other countries in terms of information capital growth. The less growth of information capital has negatively affected to develop competitiveness in ICT sector which was shown in Figure-2 and it would be the major contributor making Japan depend on import out of technology trade in ICT industry sector.

FINDINGS

Although Japan has enjoyed its advanced technology and competitiveness in manufacturing sector, on the other hand, it has struggled to develop competitiveness in ICT sector especially in software application despite the fact that Japan has world’s advanced ICT infrastructure. Because the software application side of information capital which information and knowledge are obtained has not successfully been accumulated, there is a lack on accessibility and utilization of the ICT infrastructure as shown in Figure-7. The problem is that there is no car driving on the highways invested. The figure was reflected the result of online questionnaire targeting users in the seven countries. The survey on utilization includes: 1) healthcare/welfare, 2) education/personnel, 3) employment/labor, 4) administrative services, 5) culture/arts, 6) corporate management, 7) environment/energy, 8) transportation/distribution, 9) security/safety, 10) e-commerce. It is consensus that IT itself is not valuable to improve performance or create any competitive advantages [7]. Investment in ICT infrastructure does not play any role without developing and utilizing the software applications on the basis of the infrastructure.

< Figure-7: International Rankings Relating to Utilization of ICT>

NB. Deviation value was calculated from the mean value of the sum of the rate of utilization for each area

(Source: Johotsushin Hakusho 2009, Ministry of Internal Affairs and Communication: Translated in English)
Of course it is clear that maintaining and strengthening the competitiveness in manufacturing sectors which Japan has been good at is important for sustainable economic growth, but more importantly, overcoming weakness in ICT sector by accumulating information capital especially in software applications and developing advanced software technology which could also be exported to cross-borders as well as manufacturing sector would be the most critical key factor for Japan’s economic regeneration. Japan has enjoyed its technology competitiveness in manufacturing hardware such as automobile (Toyota, Honda) and electric machinery (Sony, Cannon). On the other hand, Japan has faced the challenges to develop competitiveness in software application field. Given that in 2008 when the economy as whole shrank due to the influence of the global recession, ICT was the only sector to grow in Japan. The average contribution rate of the ICT industry to economic growth over the five years from 2002 to 2007 was about 34% [2]. Developing competitiveness in software application industry and the growth in ICT sector would be the key factor for the future economic prosperity in Japan.

COMMENTS

High security consciousness among Japanese people shown in Figure-8 to the information treatment would enlarge the reluctance to enhance information capital utilization. In many business fields, the formal and important information is still handled in paper based by traditional way in Japan. On the other hand, the utilization of blog has been rapidly growing. This phenomenon would be led because the information treated within the blog world is informal and the participants would feel less security conscious to utilize the blog.

REFERENCES


< Figure-8: Citizens’ levels of concerns about 10 safety- and security-related categories>

![Figure 8: Citizens' levels of concerns about 10 safety- and security-related categories](source: Johotsushin Hakusho 2009, Ministry of Internal Affairs and Communication: Translated in English)
DEVELOPING A REAL-TIME DECISION SUPPORT SYSTEM FOR DISASTER EVACUATION

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ABSTRACT

A scientific and effective evacuation plan plays an important role in improving the event reaction ability of the traffic system and saves rescue time and reduces property losses during a disaster. In this paper we presented a framework of Real-Time Decision Support System-Disaster based on the Open Community structure and diversion route models. Distinct from previous planning models, the Real-Time Decision Support System-Disaster Evacuation has following characteristic: (1) Integrate information based on OC platform and thus enlarge the scope of the information collection after disaster. (2) Dynamically update the evacuation plan. This paper actually lays out the framework of RDSS-DS but leaves details for further work.

Keywords: Real-Time, open community, disaster, dynamic evacuation plan.

INTRODUCTION

On 11 March 2011, an 8.9-magnitude earthquake hit off the east coast of Japan. The quake -- one of the largest in recorded history -- triggered a 23-foot tsunami that battered Japan's coast, killing hundreds and sweeping away cars, homes, buildings, and boats. As of March 21, the official death toll from Japan's devastating earthquake and tsunami passed the 10,000 and the total death toll from the disaster could rise much higher as the National Police Agency said more than 17,400 people are still missing [13]. To reduce the heavy losses in such a disaster, it has been commonly accepted that well prepared schemes to cope with the disaster, effective relief actions, and systematic recovery operations are the most important [20]. For these plans and related decisions, the timeliness, accuracy, and completeness of the information about the disaster are most crucial. The timely information can help estimate damage and impact, guide the organization of evacuation and rescue actions, particularly within the first 72 hours, and optimize resource allocations, such as logistic supply management and rescue force coordination. The key problem here is whether the communication system is still working in a disaster. If it is no longer working, there is no information for decision making. The reality is that there is still some limited information available. Taking the Japan earthquake and tsunami on 11 March 2011 as an example, the communication through cell phones in Japan was difficult because of damage to infrastructure and systems a few days after the earthquake and tsunami disaster. However, the Internet service was not affected. Under this context, the Internet can play an important role in the information collection and dissemination. Besides, the real situation of 2008 Sichuan earthquake indicated that the modern communications technologies may still exert increasing important effects after a natural disaster as long as they are properly used since there are efforts in recovering the services. It was reported that the services of Xiaolingtong, or PHS (personal handy phone service) was working well in many towns in the epicenter and became one of the major channels sending out the valuable earthquake information [3]. In another aspect, the efforts in recovering the communication systems after a disaster continuously improved the situation. Then the question is how the information can be applied to make right decisions in time to reduce the damage by the disaster.

In this paper we are to investigate an important decision making problem: the real-time evacuation scheme based on the incomplete and imperfect information in the disaster, which is dynamically updated via the crippled information system. Since the problem could be very complicated and hard to be formalized due to multiple dimensions of the issue, we narrow down this problem to the situation in a metropolitan area, when a natural disaster, such as earthquake, nuclear leak, tsunami, fire, etc., suddenly occurs. Then there are at least two facets of the research problem, which are specifically challenging:

1) How to collect the information based on deformed communication systems;  
2) How to dynamically update the evacuation plan, for example, the evacuating routes and rescue force allocation, based on the distorted information full of contradictory factors but lacking some important part;

LITERATURE REVIEW

Due to the high frequency of natural disasters, evacuation planning and management has attracted growing interest from researchers, engineers and governments for protecting people from disasters and complications [2, 10, 18, 19, 20]. Disasters could strike anytime, anywhere; take many forms; build over days or weeks, or hit suddenly without warning, and the corresponding evacuation planning is different in time, locations, scales, predictability, frequency, intensity, nature and other features. The research regarding evacuation planning mainly focus on following questions: how to estimate the evacuation time [2, 10, 18]? How to build the evacuation scheme? What are the determinants for a successful application of the information system in an
evacuation? The evacuation plan systems are the most important links in disaster emergency management, which can prevent the tense, disorder and chaotic situation after the disasters actually happened and guarantee the rescuing activities developing rapidly, orderly, and effectively thus might reduce the nonessential loss and casualties[1, 17]. Numerous techniques, methods and models have been developed and applied to evacuation management. The Regional Area Evacuation Modeling System (REMS) [14] was developed at the University of Florida to estimate the evacuation time and the traffic flow on a given transportation road network by simulation and several network optimization models incorporated into the software. Hobeika et al. [10] developed a microcomputer software package for the analysis, evaluation, and development of evacuation plans around nuclear power stations referred to as the Transportation Evacuation Decision Support System (TEDSS), The Transportation Evacuation Decision Support System (TEDSS) [11] is an outgrowth of the MASSVAC macro-level evacuation planning programs. TEDSS supports various evacuation planning and operation scenarios, such as natural disaster evacuations and man-made disaster evacuations. Dynamic Network Assignment – Simulation Model for Advanced Road Telematics (Planning Version) --DYNASMART-P [15] --FHWA supported the development of this model by the University of Maryland to support network planning and traffic operations decisions through the use of simulation-based dynamic traffic assignment. FHWA is examining the application of this model for emergency transportation management analysis. Evacuation Travel Demand Forecasting System --- this is a macro-level evacuation modeling and analysis system that was developed in the aftermath of Hurricane Floyd to address the need to forecast and anticipate large, cross-state traffic volumes [6].

However, the big challenge of evacuation activities is the movement of huge people amount involved in evacuation based on the limited information and time. Few of the previous literatures consider both factors. To generate dynamic evacuation plan with limited information, a framework of Real-time Decision Support System for Disaster Evacuation (RDSS-DE) based on Open Community (OC) and Dynamic Optimization Algorithms will be proposed.

CONCEPTUAL MODEL OF RDSS-DE

Emergency management and first responder agencies traditionally have conducted the planning process for evacuation. The planning process should take into account and involve all agencies and entities that will participate in declaring, executing, and supporting evacuation and sheltering efforts, such as governments, non-government organizations and individuals. We propose that a real-time decision support system for disaster evacuation (RDSS-DE) is one of important systems for crisis management in a disaster. We define the goal of RDSS-DE as to dynamically generate and update the evacuation plan based on the available resources to cope with the constantly changing conditions of the scene in the disaster evacuation process. The objectives of RDSS-DE include:
1) Collect and share the information in real-time after disaster;
2) Be able to process the imperfect real-time data for decision making;
3) Construct and optimize the evacuation route with the diversion route model.
4) Generate evacuation report for the auditing and review purpose.

Generally, the evacuation planning and management involves the following phases [21]:

1) Readiness Phase – It is the time when information about an incident becomes available, and decision makers use this information to determine whether an evacuation is necessary. The Readiness Phase is minimal or none during a no-notice evacuation.

2) Activation Phase –During this phase, relevant officials and agencies should be made aware that an evacuation is taking place, a command structure should be established, communication systems should be ready, Traffic Management Centers (TMC) should be activated, transportation representatives should be dispatched to the Emergency Operations Center (EOC), evacuation routes should be decided, and a determination should be made about which transportation resources will be needed. Service patrols and highway engineers may be deployed or staged along evacuation routes to aid in the evacuation.

3) Operations Tier 1 – Evacuating People from Harm’s Way – This phase involves the actual evacuation of citizens from the affected area. While there are many aspects to this phase, transportation officials should be most concerned about traffic control and traffic incident management.

4) Operations Tier 2 – Evacuee Re-Entry – This phase focuses on the re-entry of citizens back into the once-evacuated area. The Evacuee Re-Entry Phase is the same for no-notice evacuations as it is for advance notice evacuations.

5) Return to Readiness Phase – It is a transition between being operational and returning to a state of planning and preparedness. Lessons learned from the evacuation should be incorporated into existing plans so that the same mistakes are avoided and best practices are utilized during the next evacuation.

The proposed RDSS-DE helps stakeholders make decisions during the whole evacuation process, from phase one to five.

In the emergency situation after a disaster happened, openness is the key to guarantee effectiveness of the information services [8, 9]. Based on the context, Wang et al (2009) defined an open community (OC) for disaster response as a kind of virtual community but accessible via more general digital user terminals, including cellular phones, PHS
The concepts of OC is rooted in the idea of living lab proposed by William Mitchell, a professor at MediaLab, MIT, in 1990s --- “Living Labs as a research methodology for sensing, prototyping, validating and refining complex solutions in multiple and evolving real life contexts”. An OC is an implementation of living lab for productive purposes which involve value argumentation and business opportunities. Many of the innovative techniques and concepts relevant for OC’s, such as mashups [16], user-driven services, dual-model approach, and real-time mass customization, are still in their infancy state but paving the way towards next generation of IT reinforced revolution. The key success factors of open community in disaster application include easiness of joining and using the community services/tools, easiness of sharing resources, and relatively low privacy requirements. The suggested “dual model” [9] would enable a two-way-traffic from citizens to officials and from officials to citizens. The mashup techniques would be versatile to make use the data from lots of sources.

In another aspect, Xu [21] has done a comprehensive research on evacuation planning and management. The pre-developed plans help evacuation management, but do not guarantee the success of an evacuation. Even carefully laid out evacuation plans can have a diminished capacity or become ineffective because of a crash or other incident blocking a vital evacuation route. Xu [21] suggest that diversion, using adjacent arterials to divert stuck traffic, be a feasible approach to evacuation incident management due to its capability to reduce traffic volume on the freeway and distribute exceeded demand to adjacent arterials. Xu [21] has conceived a diversion routing model considering resource cost for diversion control and characters of diversion traffic in evacuation, and developed a method for real-time diversion routing in evacuation. By using the two methods together, practicable diversion routes could be obtained in real time to alleviate congestion on evacuation corridors caused by precipitating incidents.

 Updating the evacuation scheme in accordance with the constantly pouring in information is an issue of dynamic decision making (DDM) [5], which is suitable for the decisions made in “an environment that changes over time either due to the previous actions of the decision maker or due to events that are outside of the control of the decision maker” [5]. In this sense, dynamic decision tasks are different from the simple and static decision tasks in that the former is more complex and occur in real-time and involve observing the extent to which people are able to use their experience to control a particular complex system, including the types of experience that lead to better decisions over time [7]. This underpins our idea of the Real-time Decision Support System for Disaster Evacuation (RDSS-DE). With the information collected from OC and the optimal algorithms embedded in RDSS-DE, the official organizations can dynamically update the evacuation plan, which guide the evacuation and rescue actions particularly with the first 72 hours, and optimize resource allocations.

RDSS-DE consists of three fundamental components:

1) **Database**, which store the historical data of earthquake and the instant information collected from OC. Generally, there are at least three databases in RDSS-DE. The first one stores the information created a shared by citizens, while the second one is for the official organizations to store and share information. Another one store the information both from the former two databases, which is mainly used for decision making.

2) **Diversion Routing Model**, which considers resource cost for diversion control and characters of diversion traffic in evacuation, and develops a method for real-time diversion routing in evacuation. Based on the real-time information collected from the OC module, diversion routing model identifies the optimized diversion routes for evacuation plan. The proposed model was developed based on the basic minimum cost network flow model and analysis of characters of diversion traffic in evacuation [21].

3) **User interface**, which display the evacuation report. This module presents the analysis results based on the incomplete information and the diversion routing model. The report should contain the actual situation of the evacuated location and the plausible evacuation routes.

**IMPLEMENTATION OF RDSS-DS**

Based on the open community and diversion routing model in emergency response operation, a framework of RDSS-DE can be proposed as shown in Figure 1.

The RDSS-DE is triggered by an evacuation planning requirement, which is sent by the official organization such as Emergency Operations Center. Information services are provided by OC-based structure [20], which enable many kinds of telecommunication terminals, such as cell phone, PHS, satellite phone, fixed line phone, computers and PDAs. All of this information is stored in corresponding data warehouses according to the information attributes. Many basic data process and analysis tools such as Mashup are available in the OC modules, which help pre-process the data. Based on the evacuation requirement, the information about the location evacuated and the information collected instant form the evacuees are inputted into the Analysis modules. Utilizing Diversion Routing Model [21], an optimization evacuation plan is generated and sent to the Display module.

To realize the above proposed idea of RDSS-DE, there are fundamentally three research issues:

1) **Imperfect information processing**. It is realistic that the advanced communication networks will normally be damaged to certain extent during a disaster, such as earthquakes. However, based on the situation of Sichuan and Japanese earthquakes, the communication networks may still function after disasters and will continue to recover in the follow up days by the efforts of evacuation organizations. Therefore, we suggest that an open community information service environment is a good way to solve the problem of incomplete information after disasters. It has the following characteristics [20]:
light-weight, very easy and fast to use, error tolerant, dynamic, two-way (from citizens to officials and from officials to citizens), publicly accessible and autonomous. These characteristics are suitable for the emergent and underserved needs of information after disasters. In summary there are two major uses of an open community for information services during a disaster. The first one is to collect the information about the destructiveness of the disaster in the degree and scope. This information can help allocate the resources for rescue efforts. The second one is to resume the destructed social communication services for disaster relief. All the main information services after a disaster request the timely data collection such as Rescue calls, Damage report, Resource allocation, and especially for Evacuation Planning. They share the same process composed of data collection, data transmission, data authentication and processing, and information usage. Open community relieve the demand of emergency department for information during disaster since it allows individuals to share information and to interact with others even when no previous ties [8]. When forming an open community, the principles are easiness of joining and using the community services/tools, easiness of sharing resources, and relatively lower privacy requirement. Thus, a large of amount of information is generated through these interactions. With the help of the some data mining tools and information collected by OC, evacuation planning system or models can calculated the optimized evacuation routes.

To realize the proposed idea of open community, further practical considerations are necessary [20]. The data exchange mechanism in an open community involving missions of mobile hosts must be able to operate in two modes: (a) User activated mode for information and service provision and access; and (b) Automatic retrieval mode activated by officials. Furthermore, Data collected and sent after disaster event are generally provided under extreme conditions and data quality cannot be guaranteed. To evaluate the quality and usability of a set of data requires well developed techniques, such as abnormal identification, data mining based data quality classification, and so on.

2) Evacuation route and traffic throughput optimization based on imperfect and incomplete information. Although the problem of incomplete information has been relieved by OC-based information service, the weak communication networks and terrible physical situation after disasters are still big challenge for the information collection and sharing. Therefore, when we establish the evacuation plan, the incomplete

Figure 1 Framework of Real-Time Decision Support System-Disaster Evacuation
information still needs to be considered. However, few of existing evacuation algorithms considers the affect of incomplete information on the calculation of evacuation route. For example, both of the Dial’s algorithm and the Users Equilibrium algorithm \cite{10} need the information of the highway network structure and the number of vehicles produced in an emergency planning zone. Therefore, evacuation route model or algorithms is venerable to the incomplete information. When we establish the evacuation model to compute the evacuation route, the model should be robust to incomplete information.

3) **Evacuation scheme evaluation and risk management.**

There are many alternatives for evacuation plans. We need a standard to evaluate different plans and find the best one based on the standard. In this study, the optimized evacuation route is selected based on resource cost for diversion control and characters of diversion traffic in evacuation, which means that the optimized evacuation plans outperformance in resource cost and matching with the real situation. According to the previous literatures, evacuation time of each evacuation route is also an important factor when we evaluate the different routes. Evacuation time is the time required to clear all the vehicles in the network \cite{10}. Meanwhile, the number of links congested throughout the whole process is analyzed and compared when evaluating different evacuation routes. In the paper of Hobeika et al., the Dial’s algorithm and the Users Equilibrium algorithm for modeling the evacuation process are compared from the perspectives of evacuation time and congested links in the evacuation networks. The evaluation is conducted not only before the implementation of evacuation plan but also during and after the implementation. After we select the optimized evacuation route, we still need to monitor the implementation of the evacuation plan and collect the instant information of the location evacuated. Based on the new information, the evacuation route will be re-computed and selected, which realize the dynamic decision making of the optimized evacuation plan.

Furthermore, risk management of the evacuation planning also needs our attention. Whenever we make a decision, it means we have to take risk. The result of the decision is uncertain. When we choose which evacuation plan to implement, it maybe leads to some unfortunate events, such as the loss of lives. We should try out best to minimize, monitor, and control the probability and/or impact of unfortunate events. Besides the estimation of the evacuation time and congested links in a evacuation networks, the estimated loss of lives and cost of the evacuation should be calculated with the evacuation plan. Based all these factors, the comprehensive evacuation plan can be generated.

**CONCLUSION**

In this paper we presented a framework of Real-Time Decision Support System-Disaster based on the Open Community structure and diversion route models. Distinct from previous planning models, the Real-Time Decision Support System-Disaster Evacuation has following characteristic: (1) Integrate information based on OC platform and thus enlarge the scope of the information collection after disaster. (2) Dynamically update the evacuation plan. This paper actually lays out the framework of RDSS-DS but leaves details for further work.

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FIFTEEN YEARS OF INTERNET IN CHINA: TRENDS, PATTERNS, FACTORS, AND UNIQUENESS

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ABSTRACT

The current study conducted a meta analysis of twenty-six semi-annual national surveys of China’s Internet development status. It processed the survey results to obtain perspectives of four aspects: overall trends of Internet in China, determining factors of the development level of Internet applications, usage patterns of major Internet applications, and regional differences in China in Internet applications, in a fifteen-year time frame. Determining factors are found to contribute to Internet adoption, and observations are made about the Chinese Netters’ Internet usage patterns. Significant regional differences are identified. Dynamics of and relationships regarding the Internet in China are discussed.

Keywords: Internet, China, meta data, longitudinal study, determining factors.

INTRODUCTION

On December 31, 2010, the number of China’s Internet users reached a new record of 457 million[3], not only securing for China the global first place in the number of Internet users, but also has an Internet penetration rate of 34.3%, which clearly passed the world average of 28.7% [5].

China has been enjoying fast economic growth in the past three decades. The arrival of the Internet Age adds fuel to the engine of China’s economy. Millions of Chinese Internet users participate in online communications, online purchase, online sales (including auctions), and the newly emerged social networks, especially WeiBo (“microblog”) [3]. The Chinese Netters, with their population and active roles in the Internet applications, are marching toward the center stage of the Internet in front of the whole world [5].

With a gigantic population of 1.3 billion, any movement of China regarding activities on the Internet would mean tremendous opportunities for, as well as challenges to, those within and outside China. A good understanding of China’s Internet users is critical in order for China, and for all entities doing business with China, to benefit from the release of this gigantic country’s economic energy, and to tap into the huge market potential of the country’s 457 million Internet users, which is still growing at an astonishing rate of 19.1% [3].

Beginning from November 1997, China Internet Network Information Center (CNNIC) conducted each year a semi-annual survey of China’s Internet users, user behaviors, Internet infrastructure, and new trends regarding the Internet and various Internet applications in China. The surveys were conducted in June and December each year (except the first survey which was conducted in October 1997).

These surveys collected data and reported such important Chinese Internet development information as total number of Internet users, total number of Internet-connected computers, the geographical distributions of Internet users as well as that of websites, the gender, age, and occupation breakdowns of the Chinese Internet users, the most popular online activities by the Chinese Internet users, among many other interesting and important aspects of Internet applications and status in China.

The CNNIC surveys provide a rich source of data regarding China’s Internet development and applications. A careful examination of the existing twenty-seven surveys may very well help us to understand the Chinese Internet users’ view of commercial and social activities on the Internet, in order for those having a stake in China’s economy to design business plans accordingly for entering and expanding in the virtual market of the 457-million strong Chinese Internet users. At the same time, a good understanding of the Chinese Internet users would certainly help to understand this very influential (and getting more so) consumer group and social/political constituents, to help China in her transition to a full market economy with democracy and rule of law.

We collected and cleaned data from the existing CNNIC survey reports (from the second survey to the twenty-seventh survey), and conducted a secondary data analysis. The purpose was to gain understandings of China’s Internet users in their online activities and behaviors. We would also hope to discover some relationships, trends, and patterns regarding the Internet’s roles in the social and economic transition of China.

DATA AND METHODOLOGY

The study is based on the twenty-six semi-annual reports published by the CNNIC (excluding the first report in a total of twenty-seven, which was not done in the “regular” time – October rather than end of December and June as all the other reports).

The CNNIC reports are entitled “The Statistical Reports on the Development Status of China’s Inter-Networks.” The reports regularly collected the number of connected computers, the number of Internet users, the geographical distribution of these users, the distribution of information flow over the Internet in China, and the domain registration information, as well as information about websites operating
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from China. The reports also published demographical information of China’s Internet users, their usage of the Internet, and their opinions regarding “hot issues” of Internet applications.

The CNNIC reports are written in Chinese. All the reports (except the first report, which was not conducted at the regular June/December time intervals) were used for the current study. Reports were carefully read, key data excerpted, sorted, and aggregated, and data analysis tools such as graphing and statistical analyses were employed, to identify patterns and relationships, and to present the results of the analyses.

In this study, we focused our attention on the following issues and aspects:

1. The major determining factors of the development level of Internet applications as measured by the Internet penetration rate;
2. the regional differences in China in terms of Internet applications, and the trend or dynamics of the regional differences;
3. Internet user behaviors, as represented by the most conducted online activities, and their trends;
4. adoption and growth of newer Internet applications, such as SNS, and their social impacts to the Chinese society;
5. defining events in China’s Internet applications in the time frame of the study.

DATA ANALYSES AND RESULTS

The Trend of Growth for China’s Internet

Figure 1 shows the growth of Internet in China 1997-2010. From Figure 1 we can see that the number of Internet users as well as the Internet penetration rate went through a three-stage growth pattern: the first is 1997-1999, showing slow growth for both indicators, indicating an introductory phase or the work of “innovators” [8]. Then in the period of 2000-2006 both the number of Internet users and the penetration rate are picking up speed, clearly demonstrating the joining in and the contribution of “early adopters” [8]. December 2006 was a pivot point when the penetration rate reached 10.5%, from which point both the number of Internet users and the penetration rate began a high-speed increase, apparently pushed up by the “early majority” of Internet adopters.

FIGURE 1: THE GROWTH OF INTERNET IN CHINA 1997-2010: NUMBER OF INTERNET USERS AND PENETRATION RATE

Figure 2 presents the number of broadband Internet users, and the percentage of broadband users in the total Internet users. CNNIC began to survey the number of broadband users since the year 2000 since which there has been a steady and accelerated increase of broadband users. Between surveys number 19 and number 20 (December 2006 and June 2007), there began to have an accelerated increase of broadband users. This “pivot point” came at the time when the proportion of broadband users reached 2/3 of the total Internet users (66.2%). Comparing Figures 1 and 2, we can see that the pivot points of broadband users and that of the overall Internet users coexist at around the latter half of 2006 and the early part of 2007. It seems to be fairly safe to say that the “in-pouring” of broadband users played a critical role in the fast increase of the total Internet users in China.

FIGURE 2: THE NUMBER OF BROAD-BAND (BB) INTERNET USERS AND BB% AMONG TOTAL INTERNET USERS

Determining Factors of the Internet Applications

Bui, Sankaran and Sebastian [1] proposed and tested a metric of eight factors with 52 measures for the readiness of e-commerce for a country. These factors are: Knowledgeable Citizens, Access to Skilled Workforce, Macro Economy, Digital Infrastructure, Industry Competitiveness, Culture,
Ability, Willingness to Invest, and Cost of Living and Pricing. While those factors may be suitable for comparison across countries for their e-commerce readiness, when examining regions inside a country, some factors became not so relevant. Zhang and coauthors [9] proposed a simplified model in the measurement of e-government readiness. They found that the development of e-government in a given region (city or county) within a country was related to the GDP per capita of the region of interest, and the percentage of college enrollment against the total population in the same region. While GDP no doubt has relevance to most measurements of social economic development level, the college enrollment here probably signals the intensity of knowledge production and consumption in the region. College enrollment may also reflect the availability of better educated citizens to participate in the information processing necessary for the involvement of citizens in the implementation of governmental policies, and even in the policy formation and/or decision making of governmental processes (to a limited extent). It is also plausible that better educated citizens are more able to harness sophisticated technology and more effectively interact with governments in various processes, on various issues. The above is also true in the applications of other information and communications technology (ICT) in business, social life, and various aspects of individuals’ lives. Therefore, we see it fit to have GDP per capita and the proportion of college enrollment (the number of enrolled college students per one hundred thousand residents of the region) as the factors determining the level of Internet applications.

The Internet is, after all, an application of information and communications technology (ICT), and ICT relies heavily on the information technology infrastructure. An important measure of the infrastructure for the Internet is the ratio of telephone lines to the population in a given region. Therefore, we employed the measure of “number of phone lines per person” for this purpose. An advantage of this measure is that it can be calculated from the annual census reports of Chinese governments at the central and provincial level.

The Internet’s power lies in its strong capabilities for individuals to search and access virtually unlimited information that are made available to the public. The Internet is but a bridge and/or “pipeline,” and there needs to be sources of information flowing through the pipelines. Information is generated by certain activities by people, especially specific groups of people – the “knowledge workers” (Jessup and Valacich, 2008). The types of activities that generate information are typically classified in the “tertiary industry.” The development level of tertiary industry largely determines the amount and the value of available information. Hence, we used the percentage of the tertiary industry in the GDP of a given region (city, county, province) as the measurement of the level of information production and consumption.

Therefore, our model is as follows:

![Diagram of Internet Applications and Determining Factors]

**FIGURE 3: DEVELOPMENT STATUS OF INTERNET APPLICATIONS AND ITS DETERMINING FACTORS**

While GDP no doubt has relevance to most measurements of social economic development level, the college enrollment here probably signals the intensity of knowledge production and consumption in the region. College enrollment may also reflect the availability of better educated citizens to participate in the information processing necessary for the involvement of citizens in the implementation of governmental policies, and even in the policy formation and/or decision making of governmental processes (to a limited extent). It is also plausible that better educated citizens are more able to harness sophisticated technology and more effectively interact with governments in various processes, on various issues. The above is also true in the applications of other information and communications technology (ICT) in business, social life, and various aspects of individuals’ lives. Therefore, we see it fit to have GDP per capita and the proportion of college enrollment (the number of enrolled college students per one hundred thousand residents of the region) as the factors determining the level of Internet applications.

We obtained GDP per capita in all the provincial-level regions in China from China Annual Statistical Gazette at China State Bureau of Statistics’ website [4]. We obtained the enrolled college students per 100,000 populations in the corresponding regions, also from the same website. The Gazette also directly provided number of phone lines in each of the thirty-one Chinese provinces/autonomous regions and directly-administered cities (such as Beijing and Shanghai). We divided the number of phone lines by the population of each province/region to obtain the “phone line per capita” data. The percentage of tertiary industry in the local GDP was also directly provided in the Annual Statistical Gazette of the
corresponding regions.

A preliminary examination of the relationship among the number of Internet users, penetration rate and GDP per capita shows a clear pattern of correlation, as can be seen in Figure 4 below:

FIGURE 4: GDP PER CAPITA, NUMBER OF INTERNET USERS, AND INTERNET PENETRATION RATE

In Figure 4 we can clearly see that both the number of Internet users and Internet penetration rate have been increasing in a coordinated way with the per capita GDP. This is a good indication that the number of Internet users and the Internet penetration rate grow as GDP per capita grows. Another interesting observation is that, with GDP per capita increased at its own fairly steady rate 2004-2010, the Internet user number and penetration rate experienced an accelerated rate of increase ever since the penetration rate reached 10% in December 2006, a good proof of Rogers’ theory of diffusion of innovation [8]. In Figure 4, we have seen that the 10% penetration rate is indeed a “critical point,” or, in other words, the 10% population adopting the Internet is a “critical mass,” since that point the Internet adoption accelerated.

In order to identify the relationship between the Internet adoption and the other factors, we ran correlation analysis of the percentage of netters in the total population in each province, with the factors of GDP per capita, proportion of enrolled college students, percentage of tertiary industry in the GDP, and the number of phone lines per capita, all of the same region for the thirty-one provinces (including autonomous regions and directly-administered cities). The correlation coefficients are as follows (see the right column for Table 1):

From Table 1, we can see that the proportion of tertiary (service) industry, the number of phone lines per capita, and the number of enrolled college students per 100 thousand population, together with the earlier-identified GDP per capita, contribute to the Internet penetration rate. This finding supports our model presented in Figure 3.

<table>
<thead>
<tr>
<th>%Netter in population</th>
<th>Pearson Correlation</th>
<th>Phone lines per capita</th>
<th>GDP per capita</th>
<th>College enroll per 100K ppl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sig. (2-tailed)</td>
<td>0.001</td>
<td>0.000</td>
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</tr>
</tbody>
</table>

### TABLE 1: CORRELATION COEFFICIENTS AMONG POSSIBLE FACTORS OF INTERNET USAGE

Understanding the behavioral patterns of the Internet users will help businesses to more effectively provide services to the Internet users, and to develop new services and/or deliver services in new and better ways to the Internet users. Figure 5 below shows the Chinese Internet users’ reported online activity proportions. CNNIC surveys listed major online activities and asked the respondents which activities they were involved for the period of the survey (“the past six months”). Until 2006, email and search engine had been the top two applications used by the Chinese Internet users. However, after 2006 when the “critical point” of the 10% penetration rate was achieved, entertainment applications – music, online games, and video - took over and became leading applications. One interesting event happened in the year 2006 may be able to explain the change: people with college education, used to account for a prevailing majority of more than 50% of the Internet population in China, fell below the 50%-mark for the first time (43.9%), and had since then been on the decline in the proportion of Chinese netters, showing a clear trend of the Internet penetrating to people of less education. It is the fact that a large influx of people with education less than college level that “diluted” the use of emails and search engines, and increased the use of entertainment applications.

FIGURE 5: INTERNET INFORMATION/ENTERTAINMENT APPLICATIONS, AGAINST INTERNET PENETRATION RATE
What would be more meaningful and valuable to most Internet-related businesses, perhaps, would be to see the Chinese netters’ adoption of e-commerce applications – online purchase, online banking, online travel booking (hotel and airlines ticket), stock trading, etc. Figure 6 below shows just that, with major e-commerce activities (reported use percentage) plotted against the Internet penetration rate. As we expected, online purchase and online banking increased as the Internet penetration rate, so did online booking of travel (roughly; CNNIC surveys did not collect/report the data for travel booking for the years missing in the figure). The percentage of Chinese netters reporting online stock trading was an outlier here, largely affected by the large fluctuations of the Chinese stock market.

**FIGURE 6: E-COMMERCE APPLICATIONS, AGAINST INTERNET PENETRATION RATE**

The Uniqueness of the Internet in China: The Regional Differences

China is a vast country with very different climate, terrain, economic development levels, and even subcultures. It is, therefore, natural and logical for one to see very different level of development of the Internet applications, as well as different levels of usage and expertise of using the Internet by people in various regions. China is generally divided into three distinct geographical and economic-development regions: the most developed east, the most backward west, and the central region that is in between.

We obtained the data of the numbers of Internet users in thirty-one provinces/autonomous regions/ directly-administered cities in China from the CNNIC reports, and then the population data from the Annual Statistical Gazette from the State Bureau of Statistics’ website and the websites of the provincial governments. We then aggregated the total number of Netters and total populations for each of the three regions (east, central, west), and calculated the percentage of Netters in their respective regions. The following are the results:

**FIGURE 7: PERCENTAGE OF NETTERS IN THE NATION, BY REGION**

From Figure 7 we can see that the more developed Eastern region occupied the leading position since the beginning, and maintain such position through the fifteen years of time period being examined. Although the lead the Eastern region enjoys is not as drastic since 2000, the gap between the East and the Central and West regions has been fairly steady.

Another angle that might be more accurate in comparing among regions/province is to compare the number of Internet users and Internet penetration rates of the regions. The results are shown in Figures 8 and 9 respectively (these data were compiled for 2003-2010; data for earlier years will be brought in a following expansion of this paper).

From Figure 8, we can see that the number of Internet users shows disparity among the regions, with the Eastern region leading the other two, and the gap has a widening trend.

**FIGURE 8: NUMBER OF NETTERS (MILLIONS) IN THE NATION, BY REGION**

The same pattern also prevails in Internet penetration rate: the East has been leading, and enjoys a widening gap in the lead. Results shown in Figures 8 and 9 alert us that there can be a digital divide in the making (and deepening) in China. The Chinese government, NGOs, and the whole society must take this issue seriously and take quick actions to address this issue.
DISCUSSION AND CONCLUSION

This study conducted a meta analysis of twenty six semi-annual reports of China’s Internet development status by CNNIC. It examined the reports from four aspects: the overall trend of the Internet adoption in China, determining factors of the development level of Internet applications, Chinese Internet user behaviors, and the regional differences in China in Internet applications.

The growth of the number of the Internet users in China, as well as the Internet penetration rate in China, clearly are on the growth at a high rate for the fifteen years of the period examined by this study. It is interesting to note that the penetration rate had an accelerated increase since 2006, the year the Internet penetration rate reached 10% in China.

Several interesting findings of the determining factors were obtained, and it was found that the development and application level of the Internet in a region is influenced by the overall economic development level of the region, and by the development level of higher education in the region. While it is obvious that economic development level determines the development and application level of the Internet, we found that higher education development level is an important determinant for Internet application. This finding should lead to more efforts and resources committed to the development of higher education, so as to tap into the power of the Internet in the economic and social development for a region.

Our study also found that, as the Internet penetrates to populations of less education, the information/ communication-related Internet applications, such as search engine and email, would give place to the entertainment-related applications, such as gaming, audio, and video downloads/streaming. This finding would be valuable for the related industries, as well as for the regulating entities regarding intellectual property rights, as well as the protection of minors regarding adult-oriented contents.

Significant regional differences in Internet application levels were noted, with the eastern provinces in China developing significantly and persistently faster and at a higher level than provinces in the central and western provinces. This should alert decision makers in China about digital divide among different geographical regions. However, the differences in Internet application levels also present opportunities for reform and for the application and implementation of Internet technologies to help the less developed regions to catch up with their more developed counterparts, with the help of the accessibility of the ample amount of information, facilitated by the Internet.

The current study have some limitations. A major limitation is that the CNNIC’s reports changed their scope of data collection, the definition of terms and variables, and the items of data collection, which reduced the available data points in certain variables for more sophisticated statistical analyses, and sometimes made it difficult to even conduct simple comparison. Another shortcoming is that the CNNIC already performed data analyses (relatively simple or “skimming” ones), which made it difficult for deeper analyses based only on the CNNIC reports. In a further study, it is desirable to obtain the raw data (i.e., collected responses of the CNNIC surveys) from the CNNIC, so as to conduct deeper and more meaningful analyses, such as to relate various behaviors with demographic data (rather than settling with the percentage or average which didn’t give sufficient and valuable information that the analyses on the raw data would certainly obtain).

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DEFINITION OF THE B TO B EXPERIENTIAL MARKETING STRATEGIES OF HIGH TECHNOLOGY SERVICE FIRMS BY USING A DEMATEL BASED HYBRID MCDM METHOD

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ABSTRACT

The goal of experiential marketing is to establish connections in such a way that the customers respond to a product offering based on both emotional and rational response levels. Based on literature review results, the researches on experiential marketing during the past decade mainly focused on business to customer (B2C) transactions while very limited researches focused on business to business (B2B) transactions. Instead, most previous researches focused on general consumer goods industry. This research aims to investigate the factors influencing experiential marketing of high technology service firms and used the Strategic Experiential Modules and experiential provider as the tool. Finally, develop a MCDM framework for experiential marketing of the high technology service firms. Based on the result of the research, an empirical study shows that experiential marketing over B2B Company of the High-Technology service industry as well as demonstrates the effectiveness of this analytic framework. Finally, the results can also as standard criteria to apply to drawing suggestions of the high technology service operating strategy.

Keywords: Experiential Marketing, Decision Making Trial and Evaluation Laboratory (DEMATEL), Analytic Network Process (ANP), High-Technology Service industry, B2B.

1. Introduction

Experiences, events that involves a person in a memorable way [16], based marketing, or the experiential marketing, has emerged recently and become a novel marketing mindset. The traditional marketing views consumers as rational decision-makers who care about functional features and benefits; in contrast, experiential marketers view consumers as rational and emotional human beings who are concerned with achieving pleasurable experiences [3].

The traditional marketing strategy is product-based, not customer-based. Many traditional marketing managers still believe in product superiority, where the task is simply to push the product through the channel to the right target [1]. Most departments are organized around product categories and focus on pushing as many units of the same product as possible to any kind of customer. Because repeated selling of desirable products to a specific customer segment is not primary objective, traditional marketing is not really interested in-depth understanding of customers [2].

Schmitt [3] proposed that experiential marketing framework is conceptually much tighter and more focused than the classic marketing strategy model, which is hodgepodge of economic, psychological, and sociological analysis combined with some war metaphors and so-called “strategies” for the most part, it is but a list of factors to consider with few precise concepts and corresponding methodologies. When the model does focus on a specific factor (e.g., on competitive analysis), it gets so bogged down in details that it loses its practical relevance. In contrast, experiential marketing strikes the right balance and does not lose track of its goal: the management of the customer experience. And it provides a rigorous conceptual and methodological approach to achieving that goal [4].

While experiential marketing has become a cornerstone of recent advances in retailing, branding and events marketing [5], there is potential for its application in High-Technology Service industry marketing to be extended and improved. The goal of experiential marketing is to establish connections in such a way that the client responds to a product offering based on both emotional and rational response levels. By understanding what the client is likely to think and feel, it is possible to get an idea of how the customers can be steered in a direction that will relate to the product or services, and entice individuals to act on that impulse to purchase. As a result of past researches on experiential marketing which mainly focused on business to customer (B2C) like Segmenting online game customers [6], Customer experience creation [7], predict consumer behavior [8]. Transactions while very few were focused on business to business (B2B) transactions, especially for the popular industry in recent years—high-tech services. Therefore, this study considers that using experiential marketing strategies of high technology service firm is valuable.

The essence of high technology services firm requires special techniques—the traditional product-oriented sales cycle must be radically modified [9]. Dunn [9] says “High tech services are hard to buy and hard to sell but can be extremely beneficial to buyers and profitable to sellers.” Observing the above mentioned phenomenon, the purpose of the this research are divide for three points: (1) to investigate the factors influencing experiential marketing of high technology service firms; (2) defining a multiple criteria decision making (MCDM) theories based framework for experiential marketing of the high technology service firms; (3) enhancing the competitiveness of high technology service firm by using the Strategic Experiential Modules and experiential provider as the tool.

And the results can also as standard criteria for high-technology service B2B Company to apply to drawing suggestions of its operating strategy. Meanwhile, high-tech managers and investors should decide on the strength of each experiential aspect in an effort to enhance their high-tech service firm competitiveness. The paper also demonstrates how comparisons could be made while selecting the model, which gives a clear direction for high tech managers and investors when devising operating strategies and activities.

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This research will be executed based on the following procedure. At first, previous studies being related experiential marketing, high technology services, and criteria for high technology experiential marketing definitions will be reviewed. Then, the critical criteria for defining experiential marketing of high technology firms will be derived by previous reviews. The validity of the derived criteria also will be confirmed by Delphic Oracle’s Skills of Interpretation and Foresight (Delphi). The structure of the entire decision making problem will be developed by using the Decision Making Trial and Evaluation Laboratory (DEMATEL), which is based on pair comparisons of the cause and effect relationships between criteria. Finally, Weights of the criteria will be derived based on the structure being derived above using the Analytical Network Process (ANP). The proposed MCDM framework will be leveraged for selecting experiential marketing which are most suitable for the various functions of high technology service firms. After the analysis, appropriate experiential marketing of high technology service firms can be defined.

2. Literature Review

Sudharshan [10] defined marketing strategy as a function of an organization’s marketing relationships (with particular emphasis on customers and channel members), the nature of the product offer, the timing of the offer to the market and the resources that will be provided to effect market delivery.

In this research, we reviewed some strategy by literature as follows:

2.1 Experiential Marketing

Although traditional marketing provided useable strategies, tools, and concepts that helped businesses succeed in an earlier age [11]. But, traditional marketing and business concepts offer hardly any guidance to capitalize on the emerging experiential economy. Experiential marketing has grown in importance because traditional marketing has largely ignored the notion of act experiences. [12].

Successful businesses bring about loyal customers by providing unforgettable experiences. These are memorable activities created by a business through its products and services to customers [16]. Prahalad and Ramaswany [13] argued that creating personal experience would be the competitive edge for companies in the future; Schmitt [3] further claimed that experiences are formed from the interaction among different events and psychology states.

All businesses must orchestrate memorable events for their customers [14], Gilmore and Pine [15], two pioneers on the experience, asserted that: if you charge for stuff, then you are in the commodity business; if you charge for tangible things, then you are in the goods business; if you charge for the activities you perform, then you are in the service business; and if you charge for the time customers spend with you, then and only then are you in the experience business.

Experience may be defined as an event that involves a person in a memorable way [16]. This means that experiential goods cannot be treated with traditional criteria (for example, utilitarian), since they involve a greater affective component, hedonistic criteria, and customers’ personal characteristics [17].

Experiential marketing, specifically, makes the purchase process easier according to their values, their enjoyment, personality type and social group in the loose sense not traditional segmentation approaches that have become too invasive and sophisticated [13].

McGregor [18] identified that in the generally neglected experiential view, the criteria for successful consumption are essentially aesthetic in nature and hinge on an appreciation of the product for its own sake, apart from any utilitarian function that it may or may not perform [19]. Thus, the processes of experiential consumption are like the appreciation of art, emphasizing the nature of the product or service without regard to its functional utility.

Schmitt [3] argued that experiential marketing differs from traditional marketing focusing on features and benefits. Experiential marketing focuses on customer experiences, examines the consumption situation, considers customers are rational and emotional, and advocates methods and tools are eclectic.

The effect of experiential marketing on customer still needs to be discussed. But we can know that experiential marketing will become a major concept and tool in the marketing domain knowledge in the future [20]. The research of experiential consumption is getting noticed for the past years. In recent, experiential marketing can also be applicable to different businesses in different industries. Experiential marketing motivates customers to make faster and more positive purchasing decisions [21], retail leisure property [22], tourism [23] and industry and innovation [24].

Today, products that are trying to differentiate through additional free services or services that are trying to differentiate by additional free products, along with traditional CRM programmers’, are all beginning to look like commoditites. Experience is the new currency of the modern marketing landscape, because people talk about experiences every day [25].

2.2. Strategic Experiential Modules and Experiential Provider

Experiential marketing is primarily submitting from the Schmitt [3]. At the same time, he suggested five strategic experiential modules, which include sense, feel, think, act, and relate [3]. According to Schmitt [3], five experiential modules of the SEMs include the sense experiential module, the feel experiential module, the think experiential module, the act experiential module and the relate experiential module. The definitions of the five modules are provided below.

Sense experiential module: involves sensorial experiences through vision, sound, taste, smell and touch such as: good-tasting food, magnificent game images and pleasing game music. Marketing strategies based on sensorial experiences may be used to stimulation aids in the customer’s positive evaluation, stimulates their desire of consumption and add value to products and motivate customers [3].

Feel experiential module: involves customers’ inner feelings and emotions. Feel marketing aims at creating affective experiences ranging from a moderate attitude to a strong emotion of joy and pride. The experience provider intends to link closely the experience, products and customers by various means to stirring up the customers’ feeling on a specific brand name or product. When customers do have feel
experience, the joy help them to have a much more positive attitude. Emotions arise not only in the final phase of consumption, but in all phases constituting the experience [3].

Think experiential module: involves customers’ ability to generate creative thoughts and appeals to the intellect with the objective of encouraging customers to engage in elaborative and creative thinking that may result in a revaluation of the company and products. And it may also inspire customers to be interested in products and help them think centrally and separately which urges them reassess the profits from new products and services [3].

Act experiential module: is about finding out the alternative ways of doing something, alternative lifestyle and interactions. Act marketing induces customers to change physically and mentally. When customers changes, they may further change their attitudes, start group behaviors and even reinterpret the interpersonal relationship [3].

Relate experiential module: including all the above-specified experiences. The individuals experience needs to be perceived positively by others, and things through personal experience, rather than individual personality and feeling to highlight customers’ desire such as being positively. Furthermore, it also makes connection between brand and social culture and by the way influences potential community members [3].

For each kind of experience, Schmitt [3] also defined appropriate instruments that marketing managers can provide experiences to stimuli customers through a set of experience providers including (1) communications: advertising, public relations, annual reports, brochures, newsletters, and magazine, (2) visual/verbal identity: names, logos, signage, and transportation vehicles; (3) product presence: product design, packaging, and point-of-sale displays; (4) co-branding: event marketing and sponsorships, alliances and partnerships, licensing, and product placement in movies or TV; (5) environments—retail and public spaces, trade booths, corporate buildings, office interiors, and factories; (6) web sites and electronic media—corporate sites, product or service sites, online advertising, and intranets; and (7) people: sales, customer-service representatives, technical support or repair providers, and CEOs and other executives.

2.3 High Technology Services

There is no agreed definition of services. According to the American Marketing Association’s Dictionary of Marketing Terms, services are intangible or at least substantially so. If totally intangible, they are exchanged directly from producer to user, cannot be transported or stored, and are almost instantly perishable. Service products are often difficult to identify, because they come into existence at the same time they are bought and consumed. They comprise intangible elements that are inseparable; they usually involve customer participation in some important way; they cannot be sold in the sense of ownership transfer; and they have no title [26].

Services are defined as the application of specialized competences (skills and knowledge) through acts or processes for the benefits of another [27]. Services, it has argued, are not separate or distinct from tangible products because what customers buy is an offering, the complete package or bundle of benefits that includes how easy the product is to buy, how it has to be paid for, services that help the buyer get full value from the product’s use, and sometimes assistance in disposing of the residual product when finished with it [28]. On the other hand, Service also can be defined as any act or performance one party can offer to another that is essentially intangible and does not result in the ownership of anything. Its production may or may not be tied to a physical product. Increasingly, however, manufacturers, distributors, and retailers are providing value-added services, or simply excellent customer service, to differentiate themselves [14].

Services have four unique characteristics that distinguish them from goods are as follows [29] [30]. (1) Intangible: the inability of services to be touched, seen, tasted, heard, or felt in the same manner that goods can be sensed; (2) Inseparable: the inability of the production and consumption of a service to be separated. Consumers must be present during the production; (3) Variable: there is a great deal of difference in the quality of service provided by various providers, or even by the same providers at different times; and (4) Perishable: the inability of services to be stored, warehoused, or inventoried. Each characteristic poses challenges and requires certain strategies. Marketers must find ways to give tangibility to intangibles; to increase the productivity of service provider; to increase and standardize the quality of the serviced provided; and to match the supply of services with market demand [14].

As such, service became significant parameter of product differentiation and important basis of competitive advantages. After the boom of information technology branch in the 1990s the concept of high technology has become increasingly popular but still lacks of commonly definition [31]. Moriarty and Kosnik [32] defined that “High tech” as “high uncertainty about technology and the market.” And “High” means potential customers often cannot articulate what they need. The term high technology (high tech) refers to advanced or sophisticated technologies. High technologies are utilized by a wide variety of industries certain characteristics. Even definitions offered by experts. Further, they also defined technology as “the practical knowledge, know-how, skills, and artifacts that can be used to develop a new product or service and/or a new production/delivery system. Technology can be embodied in people, materials, cognitive and physical processes, plant, equipment, and tools.” This definition includes both product technology and process technology [32]. High-tech firms can also means “engaged in the design, development and introduction of new products and/or innovative manufacturing processes through the systematic application of scientific and technical knowledge” [33]. The definition shifts over time means that high technology generally refers to cutting-edge or advanced technology [31].

Some researchers described that a company is classified as high-tech if it fits the following description [34] [35]: (1) It has high levels expenditure of research-and-development; (2) It has the potential to use technology for rapid growth, and its survival is threatened by the emergence of competing technology; (3) Technological innovation is their competitiveness; (4) It has highly educated employs. A large number of scientists and engineers are employees; (5) Compared with other industries, its technology is changing at a faster rate.

Mohr, et al. [31] described that high tech can include a wide range of industries and product like robotics,
biotechnology, nanotechnology, pharmaceuticals, and medical equipment, with the focus on using technology to solve global problems; it can also include energy and transportation technologies and green building technologies. Furthermore, there are some traditional domains of “high tech” include areas such as information technology [36], computer hardware, software [37], telecommunications and Internet infrastructure [38], and consumer electronics [39], among others.

Effects of inter firm differences are investigated in the new service development phase of the innovation process. Successful innovation is crucial for firm survival in high-technology service industries [40]. The speed of technological developments and the related globalization of markets, most high-technology service providers currently experience hyper competition and exceptional turbulence in their marketplaces [41]. As a consequence of many opportunities for service innovation have created by revolutionary technological developments, while these new high-technology services potentially create significant value for providers as well as users [42]. A revolution is at work in the high technology industry: the irresistible growth of business-to-business high tech services [43]. High tech services are the firms that offering a range of sophisticated services to their corporate customers, quite different from the traditional hardware maintenance and repair services. Their business can be defined as offering value to their customers through services, based on innovative information technology (hardware and software) implemented by personnel who have required expertise and who rely heavily on methodology [44].

A list of the most significant information technology (IT) based services [45], includes professional services such as consulting [46], systems engineering, systems integration [47], support outsourcing [48], e-business services [49]. Similarly with the explosion of the internet, consumer services companies have emerged. They are mostly on-line information, electronic-transactions, and electronic business services [44].

There are some important features to make a distinction of high technology services [44]:

1. Their ownership is not transferred at the time of the purchasing; 2. They cannot be easily demonstrated before purchasing; 3. They are intangible; 4. They are location independent but time dependent; 5. Customers are associated with them; 6. They are relatively homogeneous so they can be stored and quality controlled.

The product life cycles will become increasingly short; it means an urgent need for effective, fast, and continuous innovation [50]. Therefore, the trend in the macro environment of high-tech firms has turned high-technology service is necessary.

2.4 High Tech Service Marketing Strategy

Many firms like IBM, HP—have turned to services as a way to augment their revenue streams [51]. Other companies include many of the outsource providers of information technology and business services are exist solely to provide high tech services [52].

In conjunction with the increasing importance of services in the economy, a new paradigm in the marketing field, “the services-dominant logic of marketing,” also emphasizes the role of service in companies’ strategies [27].

(1) Augment high tech product sales with services revenue.

Companies that sell a tangible high tech product such as hardware or consumer electronics can augment their product sales with services revenue in several ways. First, a company might offer consulting services in conjunction with its product sales. Second, the company might offer training, repair, or maintenance contracts to supplement its revenues from product sales. The increasing popularity of a variety of industry trade groups attests to the viability of this strategy. The goal of technology companies is to engage their development, service, and support organizations—the teams involved in delivering elements of the customer experience that lower the total cost of ownership, accelerate the business benefit of the product, and build valuable new product features that were not part of the original product purchase. Indeed, the focus on long-term customer relationships suggests that augmenting product sales with service revenues might be the best strategy for many high tech services companies.

(2) Offer “pure” high tech services.

Companies that offer high tech services might include contract research firms, consulting companies that advise customers on implementation of technology solutions, and service providers that offer outsourced information technology or business process outsourcing services to corporate customers. Some of these companies offering high tech services companies is how to leverage the customized developments made on behalf of one client to other revenue opportunities. Indeed, creating a platform for standardization of services is the key to such leverage.

(3) Use technology to improve services in traditional products companies.

For companies that offer more traditional products, issues related to the intersection of services and technology include the adoption of technologies to improve customer service or make the supply chain more efficient. To be successful, technology providers that offer technology solutions to these traditional companies must develop an intimate understanding of these customers’ industries. The technology companies will succeed only if they can communicate in the language of their customers’ business.

(4) Use technology to improve traditional services industries.

Finally, companies that offer “low-tech” services also must use technology as part of their service-delivery strategy. Many traditional service industries—not R&D-intensive services—are affected by new technological innovations. The movement to self-service technologies has allowed many industries to automate previously labor-intensive operations [53].

Both cell 3 and 4 offer the potential for introducing self-service technologies, either to consumers or to employees. A critical issue for companies is how to get consumers or employees to adopt them. Recent research has shown that, in addition to innovation characteristics and adopter characteristics, adopter readiness variables (such as their motivation and ability) play an important role in customer’s willingness to try out these new technologies [53]. Managers of these technologies can stimulate user’s
ability through training and handholding new customers, and they can stimulate users’ motivation by emphasizing the benefits such as time or cost savings.

3. Methods

3.1 The DEMATEL Method

The DEMATEL method was developed by the Battelle Geneva Institute (1) to analyze complex ‘world problems’ dealing mainly with interactive man-model techniques; and (2) to evaluate qualitative and factor-linked aspects of societal problems [54]. The applicability of the method is widespread, ranging from industrial planning and decision-making to urban planning and design, regional environmental assessment, analysis of world problems, and so forth. It has also been successfully applied in many situations, such as marketing strategies, control systems, safety problems, developing the competencies of global managers and group decision-making [55]. Furthermore, a hybrid model combining the two methods has been widely used in various fields, for example, e-learning evaluation [56] and innovation policy portfolios for Taiwan’s SIP Mall [57]. Therefore, in this paper we use DEMATEL not only to detect complex relationships and build a NRM of the criteria, but also to obtain the influence levels of each element over others; we then adopt these influence level values as the basis of the normalization supermatrix for determining ANP weights to obtain the relative importance. To apply the DEMATEL method smoothly, the authors refined the definitions based on above authors, and produced the essential definitions indicated below. The DEMATEL method is based upon graph theory, enabling us to plan and solve problems visually, so that we may divide multiple criteria into a relationship of cause and effect group, in order to better understand causal relationships. Directed graphs (also called digraphs) are more useful than directionless graphs, because digraphs will demonstrate the directed relationships of sub-systems. A digraph typically represents a communication network, or a domination relationship between individuals, etc. Suppose a system contains a set of elements, \( S = \{s_1, s_2, \ldots, s_n\} \), and particular pair-wise relationships are determined for modeling, with respect to a mathematical relationship. MR. Next, portray the relationship MR as a direct-relation matrix that is indexed equally in both dimensions by elements from the set \( S \). Then, extract the case for which the number 0 appears in the cell \((i, j)\), if the entry is a positive integral that has the meaning of: the ordered pair \((s_i, s_j)\) is in the relationship MR; it has the kind of relationship regarding that element such that \(s_i\) causes element \(s_j\). The digraph portrays a contextual relationship between the elements of the system, in which a numeral represents the strength of influence. The elements \(s_1\), \(s_2\), \(s_3\) and \(s_4\) represent the factors that have relationships in Fig.3. The number between factors is influence or influenced degree. For example, an arrow from \(s_1\) to \(s_2\) represents the fact that \(s_1\) influences \(s_2\) and its influenced degree is two. The DEMATEL method can convert the relationship between the causes and effects of criteria into an intelligible structural model of the system [55].

![Fig.3. An Example of the Directed Graph](image)

**Definition 1:** The pair-wise comparison scale may be designated as eleven levels, where the scores 0, 1, 2, ..., 10 represent the range from ‘no influence’ to ‘very high influence’.

**Definition 2:** The initial direct relation/influence matrix \( A \) is an \( n \times n \) matrix obtained by pair-wise comparisons, in terms of influences and directions between the determinants, in which \( a_{ij} \) is denoted as the degree to which the \( j^{th} \) determinant affects the \( i^{th} \) INC.

\[
A = \begin{bmatrix}
a_{11} & a_{12} & \cdots & a_{1n} \\
a_{21} & a_{22} & \cdots & a_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
a_{n1} & a_{n2} & \cdots & a_{nn}
\end{bmatrix}
\]

**Definition 3:** The normalized direct relation/influence matrix \( N \) can be obtained through Equations (1) and (2), in which all principal diagonal elements are equal to zero.

\[
z = zA = \begin{bmatrix}1/\max_j \sum^n_{i=1} a_{ij}, 1/\max_j \sum^n_{i=1} a_{ij}\end{bmatrix}, \quad i, j \in [1, 2, \ldots, n]
\]

In this case, \( N \) is called the normalized matrix. Since \( \lim_{l \to \infty} N^l = [0] \).

**Definition 4:** Then, the total relationship matrix \( T \) can be obtained using Equation (3), where \( I \) stands for the identity matrix.

\[
T = N + N^2 + \cdots + N^l = N(I - N)^{-1} \quad (3)
\]

where \( l \to \infty \) and \( T \) is a total influence-related matrix; \( N \) is a direct influence matrix and \( N = [x_{ij}]_{n \times n} \);

\[
\lim_{l \to \infty} (N^2 + \cdots + N^l)
\]

stands for a indirect influence matrix; \( [x_{ij}]_{n \times n} \).

**[Explanation]**

\[
T = N + N^2 + \cdots + N^l
= N(I + N + N^2 + \cdots + N^{l-1})(I - N)^{-1}(I - N)^{-1}
= N(I - N)^{-1}(I - N)^{-1}
= N(I - N)^{-1}, \text{ when } l \to \infty, \quad N_{ij}^l = [0]_{n \times n}
\]

where \( 0 \leq x_{ij} < 1 \), \( 0 < \sum^n_{j=1} x_{ij} \leq 1 \) and

\[
0 < \sum^n_{j=1} x_{ij} \leq 1,
\]

at least one row or column of summation is equal to 1, but not all, then \( \lim_{l \to \infty} N^l = [0]_{n \times n} \).

The \((i, j)\) element \( t_{ij} \) of matrix \( T \) denotes the direct and indirect influences of factor \( i \) on factor \( j \).

**Definition 5:** The row and column sums are separately denoted as \( r \) and \( c \) within the total-relation matrix \( T \) through Equations (4), (5), and (6).
izes the supermatrix

\[ T = [t_{ij}] \text{, } i, j \in \{1, 2, \ldots, n\} \]  

(4)

\[ r = [r_i]_{n \times 1} = \left( \sum_{j=1}^{n} t_{ij} \right)_{n \times 1} \]  

(5)

\[ c = [c_j]_{n \times 1} = \left( \sum_{i=1}^{n} t_{ij} \right)_{n \times 1} \]  

(6)

where the \( r \) and \( c \) vectors denote the sums of the rows and columns, respectively.

Definition 6: Suppose \( r_i \) denotes the row sum of the \( i^{th} \) row of matrix \( T \). Then, \( r_i \) is the sum of the influences dispatching from factor \( i \) to the other factors, both directly and indirectly. Suppose that \( c_j \) denotes the column sum of the \( j^{th} \) column of matrix \( T \). Then, \( c_j \) is the sum of the influences that factor \( i \) is receiving from the other factors. Furthermore, when \( i = j \) (i.e., the sum of the row sum and the column sum \((r_i + c_j)\) represents the index representing the strength of the influence, both dispatching and receiving), \((r_i + c_j)\) is the degree of the central role that factor \( i \) plays in the problem. If \((r_i - c_j)\) is positive, then factor \( i \) primarily is dispatching influence upon the strength of other factors; and if \((r_i - c_j)\) is negative, then factor \( i \) primarily is receiving influence from other factors [57].

3.2 The Analytic Network Process Method

The ANP method, a multi-criteria theory of measurement developed by Saaty [58], provides a general framework to deal with decisions without making assumptions about the independence of higher-level elements from lower level elements and about the independence of the elements within a level as in a hierarchy. Compared with traditional AHP (Analytic Hierarchy Process) [59] based applications which usually assume the independence between criteria, ANP, a new theory that extends AHP to deal with dependence in feedback and utilizes the supermatrix approach [58], is a more reasonable tool for dealing with complex MCDM problems in the real world. In this section, concepts of the ANP are summarized based on Saaty’s earlier works [59].

The ANP is a coupling of two parts. The first consists of a control hierarchy or network of criteria and subcriteria that control the interactions. The second is a network of influences among the elements and clusters. The network varies from criterion to criterion and a different supermatrix of limiting influence is computed for each control criterion. Finally, each of these supermatrices is weighted by the priority of its control criterion and the results are synthesized through addition for all the control criteria [60]. A control hierarchy is a hierarchy of criteria and subcriteria for which priorities are derived in the usual way with respect to the goal of the system being considered.

The criteria are used to compare the components of a system, and the subcriteria are used to compare the elements. The criteria with respect to which influence is presented in individual supermatrices are called control criteria. Because all such influences obtained from the limits of the several supermatrices will be combined in order to obtain a measure of the priority of overall influences, the control criteria should be grouped in a structure to be used to derive priorities for them. These priorities will be used to weight the corresponding individual supermatrix limits and add. Analysis of priorities in a system can be thought of in terms of a control hierarchy with dependence among its bottom-level alternatives arranged as a network as shown in Fig.4. Dependence can occur within the components and between them.

A control hierarchy at the top may be replaced by a control network with dependence among its components, which are collections of elements whose functions derive from the synergy of their interaction and hence has a higher-order function not found in any single element. The criteria in the control hierarchy that are used for comparing the components are usually the major parent criteria whose subcriteria are used to compare the elements need to be more general than those of the elements because of the greater complexity of the components.

![Fig.4. The Control Hierarchy](image-url)

Source: Saaty [58]

A network connects the components of a decision system. According to size, there will be a system that is made up of subsystems, with each subsystem made up of components, and each component made up of elements. The elements in each component interact or have an influence on some or all of the elements of another component with respect to a property governing the interactions of the entire system, such as energy, capital, or political influence. Fig.5 demonstrates a typical network. Those components which no arrow enters are known as source components such as \( C_1 \) and \( C_2 \). Those from which no arrow leaves are known as sink component such as \( C_5 \). Those components which arrows both enter and exit leave are known as transient components such as \( C_3 \) and \( C_4 \). In addition, \( C_3 \) and \( C_4 \) form a cycle of two components because they feed back and forth into each other. \( C_2 \) and \( C_4 \) have loops that connect them to themselves and are inner dependent. All other connections represent dependence between components which are thus known to be outer dependent.

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*The 11th International DSI and the 16th APDSI Joint Meeting, Taipei, Taiwan, July 12 – 16, 2011, pp.411-424*
Fig. 5. Connections in a Network  
Source: Saaty [58]

A component of a decision network which was derived by the DEMATEL method in Section 3.1 will be denoted by $C_h, h = 1, \ldots, m$, and assume that it has $n_h$ elements (determinants), which we denote by $e_{h1}, e_{h2}, \ldots, e_{hn}$. The influences of a given set of elements (determinants) in a component on any element in the decision system are represented by a ratio scale priority vector derived from paired comparisons of the importance of one criterion and another criterion with respect to the interests or preferences of the decision makers. This relative importance value can be determined using a scale of 1–9 to represent equal importance to extreme importance [28]. The influence of elements (determinants) in the network on other elements (determinants) in that network can be represented in the following supermatrix:

$$W = \begin{bmatrix} c_1 & c_2 & \cdots & c_n \\ e_{11} & w_{11} & \cdots & w_{1n} \\ \vdots & \vdots & \ddots & \vdots \\ e_{m1} & w_{m1} & \cdots & w_{mn} \end{bmatrix}$$

A typical entry $W_{ij}$ in the supermatrix, is called a block of the supermatrix in the following form where each column of $W_j$ is a principal eigenvector of the influence of the elements (determinants) in the $i^{th}$ component of the network on an element (determinants) in the $j^{th}$ component. Some of its entries may be zero corresponding to those elements (determinants) that have no influence.

$$W_j = \begin{bmatrix} w_{ij1} & w_{ij2} & \cdots & w_{ijh_i} \\ w_{i2j} & w_{i2j} & \cdots & w_{i2h_{i2}} \\ \vdots & \vdots & \ddots & \vdots \\ w_{inj} & w_{inj} & \cdots & w_{inj_{ih_i}} \end{bmatrix}$$

After forming the supermatrix, the weighted supermatrix is derived by transforming all columns sum to unity exactly. This step is very much similar to the concept of the Markov chain in terms of ensuring that the sum of these probabilities of all states equals 1. Next, the weighted supermatrix is raised to limiting powers, such as Equation (7) to get the global priority vector or called weights [61].

$$\lim_{\theta \to \infty} W^\theta$$  \hspace{1cm} (7)

In addition, if the supermatrix has the effect of cyclicity, the limiting supermatrix is not the only one. There are two or more limiting supermatrices in this situation, and the Cesaro sum would need to be calculated to get the priority. The Cesaro sum is formulated as follows.

$$w = \lim_{\theta \to \infty} \frac{1}{\theta} \sum_{j=1}^{\theta} W_j^\theta$$

To calculate the average effect of the limiting supermatrix (i.e. the average priority weights can be shown by the vector $w$ ) where $W_j$ denotes the $j^{th}$ limiting supermatrix. Otherwise, the supermatrix would be raised to large powers to get the priority weights [15]. The weights of the $k^{th}$ determinants derived by using the above ANP processes, namely $w_k, k \in \{1, 2, \ldots, n\}$, will be used as weights for aggregating the performance score versus each alternative.

### 3.3 Grey Relational Analysis

Since Deng [62] proposed Grey theory, related models have been developed and applied to MCDM problems. Similar to fuzzy set theory, Grey theory is a feasible mathematical means that can be used to deal with systems analysis characterized by inadequate information. Fields covered by the Grey theory include systems analysis, data processing, modeling, prediction, decision-making, and control engineering [63]. In this section, we briefly review some relevant definitions and the calculation process for the Grey Relation Model. This research modified the definitions by Chiou and Tseng [64] and produced the definitions indicated below. GRA is used to determine the relationship between two sequences of stochastic data in a Grey system. The procedure bears some similarity to pattern recognition technology. One sequence of data is called the ‘reference pattern’ or ‘reference sequence,’ and the correlation between the other sequence and the reference sequence is to be identified [64]. The relationship scale also may be designated into eleven levels, where the scores 0, 1, 2, …, 10 represent the range from ‘no relationship’ to ‘very high relationship’ between the specified evaluation criteria and the fuel cell technologies. The initial relationship matrix $G$ is a $m \times n$ matrix, where there are $m$ ($k = 1, 2, \ldots, m$) fuel cell technologies and $n$ criteria ($j = 1, 2, \ldots, n$), obtained by surveying the relationships, where $g_{kj}$ is denoted as the relationship between the $j^{th}$ criterion and the $k^{th}$ technology.

$$G = \begin{bmatrix} g_{11} & \cdots & g_{1j} & \cdots & g_{1n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ g_{k1} & \cdots & g_{kj} & \cdots & g_{kn} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ g_{m1} & \cdots & g_{mj} & \cdots & g_{mn} \end{bmatrix}$$

The normalized relationship matrix $G$ can be obtained through Equations (9) and (10).

$$x_k(j) = \frac{g_{kj}}{\text{aspiration value } x_k(j)}$$  \hspace{1cm} (9)
and the

\[\begin{align*}
X &= \begin{bmatrix}
x_1(1) & \cdots & x_1(j) & \cdots & x_1(n) \\
\vdots & & \ddots & & \vdots \\
x_k(1) & \cdots & x_k(j) & \cdots & x_k(n) \\
\vdots & & \ddots & & \vdots \\
x_m(1) & \cdots & x_m(j) & \cdots & x_m(n)
\end{bmatrix}
\end{align*}\]

(10)

In this case, let \( x_0 \) be the aspiration-value vector with \( n \) criteria:

\[x_0 = (x_0(1),\ldots,x_0(j),\ldots,x_0(m)) = (10,...,10,...,10)\]

and the matrix containing the normalized mapping information of each strategy (fuel cell technology) to the innovation competence (criteria), be one of the \( m \) strategic patterns with \( n \) criteria to be compared with the aspiration vector \( x_0 \) where \( x_k \) is written as: when \( x_k = x_k(j) \), \( j = 1,2,...,n \) in Eqs (9) and (10), then \( x_k = (x_k(1),\ldots,x_k(j),\ldots,x_k(n)) \), \( k = 1,2,...,m \). How much grade of strategy \( x_k \) close to aspiration level \( x_0 \) in cell technology. Let \( X \) be a normalized strategic performance set of grey relations, \( x_0 \in X \) the aspiration level for referential sequence, and \( x_k \in X \) the \( k \)th strategy for comparative sequence; with \( x_0(j) \) and \( x_k(j) \) representing the numerals at criterion \( j \) for \( x_0 \) and \( x_k \) respectively. If \( \gamma(x_0(j), x_k(j)) \) and \( \gamma(x_0, x_k) \) are real numbers, and satisfy the grey axioms being defined in Deng [65], then call \( \gamma(x_0(j), x_k(j)) \) the grey relation coefficient, and the grade of the grey relation \( \gamma(x_0, x_k) \) is the average value of \( \gamma(x_0(j), x_k(j)) \). Deng also proposed a mathematical equation for the grey relation coefficient, as follows:

\[
\gamma(x_0(j), x_k(j)) = \min_k j \left[ x_0(j) - x_k(j) \right] + \zeta \max_k j \left[ x_0(j) - x_k(j) \right]
\]

(11)

where \( \zeta \) is the coefficient ( \( \zeta \in [0,1] \) ). Generally, \( \zeta = 0.5 \).

Based on Deng [8], if the grey relation coefficient in \( x_k(j) \) corresponding to \( x_0(j) \) is \( \gamma(x_0(j), x_k(j)) \), then the grey relation grade in \( x_k \) corresponding to \( x_0 \), \( \gamma(x_0, x_k) \), must satisfy the following four axioms:

1. Norm

Interval \( 0 < \gamma(x_0(j), x_k(j)) \leq 1 \), \( \forall j \); \( \gamma(x_0, x_k) = 1 \) iff \( x_0 = x_k \); \( \gamma(x_0, x_k) = 0 \) iff \( x_0, x_k \in \emptyset \);

where \( \emptyset \) is an empty set.

2. Duality Symmetric

\( x, y \in X \Rightarrow \gamma(x, y) = \gamma(y, x) \) iff \( X = \{x, y\} \).

3. Wholeness

\( \gamma(x_k, x_k) = \gamma(x_k, x_k) \)

iff \( X = \{x_k\} \); \( k = 0,1,...,m \); \( m > 2 \).

4. Approachability

\( \gamma(x_0(j), x_k(j)) \) decreases when \( \|x_0(j) - x_k(j)\| \)

increases.

If \( \gamma(x_0, x_k) \) satisfies the four grey relation axioms, then \( \gamma \) is called the Grey Relational Map. If \( \Gamma \) is the entirety of the grey relational map, \( \gamma \in \Gamma \) satisfies the four axioms of the grey relation, and \( X \) is the factor set of the grey relation, then \((X, \Gamma)\) will be called the grey relational space, while \( \gamma \) is the specific map for \( \Gamma \). Let \((X, \Gamma)\) be the grey relational space, and if \( \gamma(x_0, x_1), \gamma(x_0, x_2), \ldots \gamma(x_0, x_q) \) satisfy \( \gamma(x_0, x_k) > \gamma(x_0, x_p) \ldots \gamma(x_0, x_q) \) then we have the grey relational order: \( x_k > x_p \ldots x_q \). When the grey relational coefficient is conducted with respect to various fuel cell technologies, we can then derive the grade of the grey relation \( \gamma(x_0, x_k) \) between the reference alternative

\[
\gamma(x_0, x_k) = \sum_{j=1}^{n} w_j \times \gamma(x_0(j), x_k(j)).
\]

(12)

where \( j \) is the number of criteria (innovation competences), \( w_j \) expresses the weight of the \( j \)th criterion, by ANP and \( \gamma(x_0, x_k) \) represents the grade of grey relation in \( x_k \) (shown as \( k \)th manufacturing or logistics strategy) correspondence to \( x_0 \) (aspiration level). In this study, we make the order of the strategies following the grade of grey relation.

4. Empirical Study

This chapter shows the integrated circuit (IC) design service industry introduction first. The aspect and criteria influencing the IC design service industry by using experiential marketing strategy will be discussed in the second section. Then, an empirical study on experts’ opinions will be leveraged for verifying the feasibility of the proposed analytic framework.

4.1 IC design service industry Introduction

A revolution is at work in the high tech industry: there is an unstoppable growth of business-to-business high-tech services [43]. IC design service firms are typical examples of knowledge-based labor intensive high-tech firms. According to James [64], IC design service industry is a high technology knowledge industry. This industry requires professional engineering technology knowledge, high speed internet networks, a convenient communication digital platform, a high performance supply chain system, and a staff of highly skilled experts, who must be paid regardless of whether they're actually working on a project for the IC design industry [66].

To enhance the design service capabilities, and thus innovation competences, design service firms keep looking for external engineering, financial, intellectual property, and R&D, as well as human resources, while continuously enhancing internal engineering, marketing, and sales as well as turnkey capabilities through different Open R&D strategies, including alliances, R&D contracts, etc [67].

In recent year, more IC design or system companies are leaning toward the use of IC design service firms in making their chips to market on time and within budget [67]. The major function of IC design service is to act as a mediator between IC design and manufacturing, providing IC
designers with an IP library, IP integration and customized modification, and IC manufacturing process technique to reduce not only the development cost but also design time [68]. Furthermore, the IC design service companies provide turnkey solutions to produce ASICs and/or handle the manufacturing process in the comprehensive supply chain. The solutions provided include wafer foundry, IC packaging, IC testing, reliability qualification, failure analysis and logistic service. In return, the traditional IC design companies can focus on their core competence of product design, as well as becoming the marketing and sales channels which define the product specifications [66].

Although design service firms expanded innovation competences through various open innovation strategies, defining the optimum open innovation strategies and developing the competitive advantages has become the major concern for top managements of the design service firms [67].

4.2 Empirical Study in Experiential Marketing

There were 11 engineering experts work in the IC design service company with more than 6-years working experiences. They were invited to evaluate each of the twenty-one criteria belong to five aspects, the aspects and criteria are summarized below in Table 4-1. Further, definitions of the criteria are provided in Table 4-2 as a foundation for this research.

Table 4-1 Aspect and Criteria for the IC design service industry

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sense</td>
<td>(c_1) Company</td>
</tr>
<tr>
<td></td>
<td>(c_2) Enterprise</td>
</tr>
<tr>
<td></td>
<td>(c_3) Transaction Content</td>
</tr>
<tr>
<td></td>
<td>(A_1) Product Design</td>
</tr>
<tr>
<td></td>
<td>(c_4) Style Performance</td>
</tr>
<tr>
<td></td>
<td>(c_5) Decoration and</td>
</tr>
<tr>
<td></td>
<td>(c_6) Service Attitude</td>
</tr>
<tr>
<td>Feel</td>
<td>(c_7) Trading Arrangement</td>
</tr>
<tr>
<td></td>
<td>(A_2) Face to Face Interaction</td>
</tr>
<tr>
<td></td>
<td>(c_8) Emotional Advertising</td>
</tr>
<tr>
<td>Aspect</td>
<td>Criteria</td>
</tr>
<tr>
<td>--------</td>
<td>----------</td>
</tr>
<tr>
<td>Think</td>
<td>(c_11) Professional</td>
</tr>
<tr>
<td></td>
<td>(c_12) Pricing Strategy</td>
</tr>
<tr>
<td></td>
<td>(A_3) Induced Simulation</td>
</tr>
<tr>
<td></td>
<td>(c_13) Brand Value</td>
</tr>
<tr>
<td></td>
<td>(c_14) After-sale Service</td>
</tr>
<tr>
<td></td>
<td>(c_15) Experience</td>
</tr>
<tr>
<td></td>
<td>(A_4) Trading Interactive</td>
</tr>
<tr>
<td></td>
<td>(c_16) Brand Community</td>
</tr>
<tr>
<td></td>
<td>(A_5) Social Norms</td>
</tr>
<tr>
<td></td>
<td>(c_17) Group Attribution</td>
</tr>
</tbody>
</table>

Since the inter-relationship for individual dimensions between criteria which are summarized through the literature review and professional experts based brainstorming process. All of the criteria of the aspects decision problem structure will be deducted by using the DEMATEL method which was introduced in Chapter 3.4.

At first, the direct relation matrix $A_1$ is introduced as shown in Figure 4-1(a) according to the experts’ opinions on pairwise comparisons in terms of influence and direction between evaluation criteria. After that, the normalized direct relation matrix $N_1$ is based on Equation (1) and the normalized direct relation matrix $N_1$ is shown in Figure 4-1(b). Finally, the total relationship matrix $T_1$ is deducted based on Equation (4) and shown in Figure 4-1(c).

![Matrix](https://example.com/matrix.png)

The 11th International DSI and the 16th APDSI Joint Meeting, Taipei, Taiwan, July 12 – 16, 2011, pp.411-424
Figure 4-3(b) The Normalized Direct Relation Matrix $N_3$

$N_3 = \begin{bmatrix}
0.000 & 0.260 & 0.294 & 0.232 & 0.209 \\
0.203 & 0.000 & 0.243 & 0.254 & 0.220 \\
0.186 & 0.288 & 0.000 & 0.254 & 0.169 \\
0.169 & 0.215 & 0.181 & 0.000 & 0.169 \\
0.164 & 0.237 & 0.237 & 0.232 & 0.000
\end{bmatrix}$

Figure 4-3(c) The Total Relationship Matrix $T_3$

Then, the row and column sum is separately denoted as $r$ and $e$ within the total relationship matrix $T$ using by equation (5) and (6), and the casual diagram could be derived by mapping a dataset of $(r + c, r - c)$. In the following tables, the values of $r + c$ and $r - c$ for each criterion are demonstrated.

Table 4-3 The Degree of full Influence under Sense aspect

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Criteria</th>
<th>$r + c$</th>
<th>$r - c$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sense ($A_1$)</td>
<td>(c1) Company Promotion</td>
<td>8.865</td>
<td>-1.043</td>
</tr>
<tr>
<td>(c2) Enterprise Environment</td>
<td>7.615</td>
<td>0.159</td>
<td></td>
</tr>
<tr>
<td>(c3) Transaction Content</td>
<td>8.161</td>
<td>-0.088</td>
<td></td>
</tr>
<tr>
<td>(c4) Product Design</td>
<td>8.433</td>
<td>0.344</td>
<td></td>
</tr>
<tr>
<td>(c5) Style Performance</td>
<td>8.690</td>
<td>0.350</td>
<td></td>
</tr>
<tr>
<td>(c6) Decoration and equipment</td>
<td>7.395</td>
<td>0.278</td>
<td></td>
</tr>
</tbody>
</table>

Remark: The Shaded number is the Highest in Each Column

Table 4-5 The Degree of full Influence under Think aspect

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Criteria</th>
<th>$r + c$</th>
<th>$r - c$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Think ($A_2$)</td>
<td>(c1) Professional Knowledge</td>
<td>14.314</td>
<td>1.583</td>
</tr>
<tr>
<td>(c2) Pricing Strategy</td>
<td>15.643</td>
<td>-0.551</td>
<td></td>
</tr>
<tr>
<td>(c3) Brand Value</td>
<td>15.130</td>
<td>0.335</td>
<td></td>
</tr>
<tr>
<td>(c4) Induced Stimulation</td>
<td>14.229</td>
<td>-1.664</td>
<td></td>
</tr>
<tr>
<td>(c5) After-sale Service</td>
<td>13.708</td>
<td>0.686</td>
<td></td>
</tr>
</tbody>
</table>

Remark: The Shaded number is the Highest in Each Column

Table 4-6 The Degree of full Influence under Act aspect

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Criteria</th>
<th>$r + c$</th>
<th>$r - c$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Act ($A_3$)</td>
<td>(c1) Trading Interactive</td>
<td>32.22</td>
<td>-1.000</td>
</tr>
<tr>
<td>(c2) Experience</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Remark: The Shaded number is the Highest in Each Column

Table 4-7 The Degree of full Influence under Relate aspect

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Criteria</th>
<th>$r + c$</th>
<th>$r - c$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relate ($A_4$)</td>
<td>(c1) Brand Community</td>
<td>24.160</td>
<td>0.277</td>
</tr>
<tr>
<td>(c2) Social Norms</td>
<td>20.269</td>
<td>-0.236</td>
<td></td>
</tr>
<tr>
<td>(c3) Group Attribution</td>
<td>24.166</td>
<td>-0.042</td>
<td></td>
</tr>
</tbody>
</table>

Remark: The Shaded number is the Highest in Each Column

Table 4-8 The Degree of full Influence between Aspect

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Criteria</th>
<th>$r + c$</th>
<th>$r - c$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sense ($A_1$)</td>
<td>22.821</td>
<td>1.097</td>
<td></td>
</tr>
<tr>
<td>Feel ($A_2$)</td>
<td>23.476</td>
<td>-1.234</td>
<td></td>
</tr>
<tr>
<td>Think ($A_3$)</td>
<td>23.136</td>
<td>0.242</td>
<td></td>
</tr>
<tr>
<td>Act ($A_4$)</td>
<td>23.518</td>
<td>-0.389</td>
<td></td>
</tr>
<tr>
<td>Relate ($A_5$)</td>
<td>22.395</td>
<td>0.284</td>
<td></td>
</tr>
</tbody>
</table>

Remark: The Shaded number is the Highest in Each Column

Source: This Study

Base on the definitions of the ANP procedures in Chapter 3, the weights versus each criterion were derived.

Based on the decision problem structure being derived by the DEMATEL, the ANP method can be applied for calculating the weight versus each criterion. Pair-wise comparison results for the importance level of criteria being connected to the same goal are deprived according to experts’ opinions and were provided as inputs for the ANP. With the aid of the Super Decision [60], a software which is used for decision-making with dependences and feedbacks by
implementing the ANP, the limit super matrix $W$ is calculated and shown in all of Figure 4-13. Then, the performance values of the evaluation criteria being rated against each criterion and aggregated are presented in all of Table 4-9.

**Table 4-9 The Weights of experiential marketing evaluation criteria**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>$c_7$</th>
<th>$c_5$</th>
<th>$c_4$</th>
<th>$c_3$</th>
<th>$c_2$</th>
<th>$c_1$</th>
<th>$c_0$</th>
<th>$c_{in}$</th>
<th>$c_{out}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>0.053</td>
<td>0.041</td>
<td>0.048</td>
<td>0.067</td>
<td>0.047</td>
<td>0.048</td>
<td>0.066</td>
<td>0.053</td>
<td>0.061</td>
</tr>
</tbody>
</table>

Source: This Study

After constructing the structure of the decision problem, weights versus each criterion was derived by using the ANP (refer Table 4-8). The GRA is applied to derive the relationships between criteria and Experiential Strategies then.

The experiential strategies being reviewed in Section 2.2.1 including (1) Communications, (2) Visual/verbal identity, (3) Product presence, (4) Co-branding, (5) Spatial Environments, (6) Web sites and electronic media, and (7) Staff will be introduced to enhance the selected experiential strategy.

The initial relationship matrix for deriving experiential strategy, $G_1$, is a $20 \times 7$ matrix, where there are seven experiential strategies and twenty determinants for high technology industry, obtained by surveying the relationships. The normalized relationship matrix $X_1$ can be obtained through Equations (9) and (10). The grey relation coefficients can be calculated by using Equation (11). By setting the distinguished coefficient $\zeta$ as 0.5, the Grey relation coefficients were derived. Then the grades of Grey relation $\gamma(x_0, x_i)$ were derived. We established the result that Type 3$\rightarrow$Type 1$\rightarrow$Type 4$\rightarrow$Type 7$\rightarrow$Type 2$\rightarrow$Type 5$\rightarrow$Type 6. Finally, the Grey grades versus each experiential strategy can be derived and shown in Table 4-9.

**Table 4-9 The grades of Grey relation with respect to experiential strategy (\(\zeta = 0.5\))**

<table>
<thead>
<tr>
<th>Type</th>
<th>Experiential Strategy</th>
<th>Grey Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Communications</td>
<td>0.703</td>
</tr>
<tr>
<td>2</td>
<td>Visual/verbal identity</td>
<td>0.597</td>
</tr>
<tr>
<td>3</td>
<td>Product presence</td>
<td>0.706</td>
</tr>
<tr>
<td>4</td>
<td>Co-branding</td>
<td>0.690</td>
</tr>
<tr>
<td>5</td>
<td>Spatial Environments</td>
<td>0.485</td>
</tr>
<tr>
<td>6</td>
<td>Web sites and electronic media</td>
<td>0.697</td>
</tr>
</tbody>
</table>

Source: This Study

5. Discussion

Based upon experiential marketing strategy derived using Delphi, the decision problem being structured by DEMATEL, weighting each experiential criterion versus the goal of the decision problem by ANP, and the resulting experiential strategy portfolio was derived by mapping competences by GRA and then deriving the most important experiential strategy by gray grades. An empirical analysis based on design service firms was used to illustrate the analytical procedures.

In the “Sense Aspect”, the shaded number of the criterion Company Promotion (8.863) stands for the criterion with the highest $(r + c)$ value. That is the connections between the criteria with other criteria are strong as well as Company Promotion plays the central role in the decision problem. Meanwhile, the shaded number of the criterion Style Performance (0.350) stands for the highest $(r - c)$ value. Style Performance serves as the main influence dispatching criterion which affects other criteria. The $(r + c)$ value of the criteria Decoration and equipment (7.395) is the lowest. This means that it is neither an influence dispatching criterion nor an influence receiving criterion. The criterion Company Promotion (-1.043) is with the lowest $(r - c)$ value which implies that it is the main criterion of receiving influence from other criteria.

In the “Feel Aspect”, the shaded number of the criterion Face to Face Interaction (16.111) stands for the criterion with the highest $(r + c)$ value. That is the connections between the criterions Face to Face Interaction with other criteria are strong as well as Face to Face Interaction plays the central role in the decision problem. Meanwhile, the shaded number of the criterion Face to Face Interaction (0.586) stands for the highest $(r - c)$ value. Face to Face Interaction serves as the main influence dispatching criterion which affects other criteria. The $(r + c)$ value of the criteria Emotional Advertising (12.343) is the lowest. This means that is neither an influence dispatching criterion nor an influence receiving criterion. Criterion Emotional Advertising (-0.497) is with the lowest $(r - c)$ value which implies that Emotional Advertising Emotional Advertising is the main criterion of receiving influence from other criteria.

In the Think Aspect, the shaded number of the criterion Pricing Strategy (15.643) stands for the criterion with the highest $(r + c)$ value. That is the connections between the criterion Pricing Strategy with other criteria are strong as well as Pricing Strategy plays the central role in the decision problem. Meanwhile, the shaded number of the criterion Professional Knowledge (1.863) stands for the highest $(r - c)$ value. Professional Knowledge serves as the main influence dispatching criterion which affects other criteria. The $(r + c)$ value of the criteria After-sale Service (13.708) is the lowest. This means that is neither an influence dispatching criterion nor an influence receiving criterion. Criterion Induced Stimulation (-1.664) is with the lowest $(r - c)$ value which implies that Induced Stimulation is the main criterion of receiving influence from other criteria.

In the Act Aspect, the shaded number of the criterion Trading Interactive (32.2) and Experience (32.2) stands for the criterion with the highest $(r + c)$ value. That is the
connections between the criterion Trading Interactive and Experience with other criteria are strong as well as Trading Interactive and Experience plays the central role in the decision problem. Meanwhile, the shaded number of the criterion Experience (1.000) stands for the highest \((r - c)\) value. \((c_i)\) serves as the main influence dispatching criterion which affects other criteria. The \((r + c)\) value of the criteria Trading Interactive (32.2) and Experience (32.2) is the lowest. This means that neither an influence dispatching criterion nor an influence receiving criterion. Criterion Trading Interactive (-1.000) is with the lowest \((r - c)\) value which implies that Trading Interactive is the main criterion of receiving influence from other criteria.

In the Relate Aspect, the shaded number of the criterion Group Attribution (24.166) stands for the criterion with the highest \((r + c)\) value. That is the connections between the criterion Group Attribution with other criteria are strong as well as Group Attribution plays the central role in the decision problem. Meanwhile, the shaded number of the criterion Brand Community (0.277) stands for the highest \((r - c)\) value. Brand Community serves as the main influence dispatching criterion which affects other criteria. The \((r + c)\) value of the criteria Social Norms (20.269) is the lowest. This means that neither an influence dispatching criterion nor an influence receiving criterion. Criterion Social Norms (-0.236) is with the lowest \((r - c)\) value which implies that Social Norms is the main criterion of receiving influence from other criteria.

Finally, between Aspect, the shaded number of the aspect Act (23.518) stands for the aspect with the highest \((r + c)\) value. That is the connections between the aspect Act with other aspect are strong as well as Act plays the central role in the decision problem. Meanwhile, the shaded number of the aspect Sense (1.097) stands for the highest \((r - c)\) value. Sense serves as the main influence dispatching aspect which affects other aspect. The \((r + c)\) value of the aspect Relate (22.595) is the lowest. This means that neither an influence dispatching aspect nor an influence receiving aspect. Aspect Feel (-1.234) is with the lowest \((r - c)\) value which implies that Feel is the main aspect of receiving influence from other aspect.

After determining the relationship structure between dimensions of the evaluating systems, the ANP method is applied to derive the weights of the criteria. These pairwise comparisons are based on Saaty’s 9-point scale and represent the importance of one element over another. By calculating the limiting power of the weighted supermatrix, the top three priorities weights in the evaluating systems are: Professional Knowledge (0.063), Service Attitude, Face to Face Interaction and Pricing Strategy (0.061), Product Design and Brand Value (0.060).

After constructing the structure of the decision problem, weights versus each criterion was derived by using the ANP. The GRA is applied to derive the relationships between criteria and Experiential Strategies then. In this research, seven experiential provider’s strategies: (1) communicate (2) verbal and visual recognition (3) Product Presence (4) co-branding (5) Spatial Environment (6) Web Sites and Electronic Media (7) Staff were proposed for enabling the experiential marketing strategy of the high technology service industry. The top three priorities experiential strategies in the evaluating systems are: Product presence, Communications and People. It means that high technology firm’s manager can upgrade their competence through those three strategies.

6. Conclusions

Because of high-tech firm’s marketing strategy almost similar and IC design service plays an important role in semi-conductor industry development, and it is an emerging business model in the IC design era, furthermore, few firms used experiential marketing strategy to regard as the high technology firm’s tactic. Therefore, developing a Strategic Experiential Modules and comparing its suitability to major alternatives are needed for managers to sharpen their competitive edge. The thesis presents a multi-criteria decision model for selecting appropriate experiential strategy for high-tech firms. The process of deriving the solution is illustrated through an easy-to-understand empirical study. Results demonstrate that the model can provide a framework to assist policymakers to use SEMs strategy and making a dispassionate and objective selection.

These criteria in the thesis provide assistance, convenience and a good experience not only to the clients, those experiential marketing strategy can also be developed for the high-technology service firm. Meanwhile, high-tech managers and investors should decide on the strength of each experiential aspect in an effort to enhance their high-tech service firm’s competences, scale, profitability capabilities and revenue. This thesis also demonstrates how comparisons could be made while selecting the model, which gives a clear direction for high tech managers and investors to apply to drawing suggestions of the high technology service operating strategies and activities.

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Outsourcing support functions: Identifying and managing the good, the bad, and the ugly. Business Horizons, 52(4), 347-356.


DOES MARKET TIMING MAKE SENSE IN TAIWAN?

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ABSTRACT

This study investigates whether investors can effectively time the stock market in Taiwan. Test results uniformly favor a simple market timing trading strategy guided by discount rate changes. It outperforms both buy-and-hold and sector rotation strategies in the two subperiods as well as the entire sample period. Thus, this study supports market timing as a time-proven, useful investment tool and discount rate changes as an effective market timing indicator. In contrast, the research casts doubt on sector rotation as a viable market timing strategy, particularly once transaction costs and sector ETFs and mutual funds scarcity in Taiwan are factored in.

Keywords: discount rate changes, market timing, sector rotation, buy and hold, Taiwan

I. INTRODUCTION

Conventional wisdom in finance posits that no one can consistently beat the market. This, in turn, leaves buy and hold as a logical investment choice. However, this strategy has faced its challenges from time to time, most recently in the post-millennium era. Due to the 2000-2002 and 2007-2009 bear markets, a buy-and-hold portfolio formulated at the peak of 2000 in the U.S. would still be in the red today. In contrast, market timers argue that market timing, an actively managed investment strategy, should yield a better performance than a passive buy-and-hold strategy. As a result, market timing strategy has been closely studied in finance literature.

Previous empirical work suggests that stock returns are significantly related to monetary policy changes. Thus, market timers frequently rely on monetary policy indicators such as bank reserves, discount rate, federal funds rate, and money supply as signals to enter or exit the market. If market timing is productive, investors over the dreary past decade might have been better off had they followed certain economic indicators and formed market timing strategies accordingly.

Reference [35] finds that investors can benefit from a market timing trading strategy that is guided by discount rate changes. Specifically, investors following the strategy will enter the market upon an initial discount rate cut and stay fully invested until the rate cut runs its complete course. Once the discount rate change reverses its direction, investors will liquidate their position in the market and switch their entire portfolio holding to riskless assets such as short-term Treasury securities until the next round of discount rate increases. It shows that the formulated market timing trading strategy (the standard market timing trading strategy hereafter) clearly outperforms the benchmark market portfolio. Reference [7] extends [35] to the investigation of seven developed countries and produces similar empirical support for market timing.

Reference [10] suggests that changes in Federal Reserve monetary policy serve as an effective economic indicator to guiding asset allocations. Reference [11] reveals that expansive monetary policy favors cyclical stocks while restrictive monetary policy benefits noncyclical stocks. It, in turn, proposes a sector rotation strategy that bases its asset shifts among U.S. equity sectors on changes in monetary policy. In specific, the monetary-policy-guided portfolio rotates between cyclical industry sectors during expansive monetary periods and noncyclical industry sectors during restrictive monetary periods. It concludes that the monetary policy is successful at guiding the sector rotation strategy, which outperforms the market as a whole.

Extending [11] [35], this study evaluates the performance of the two respectively proposed active trading strategies—standard and sector rotation—against each other as well as in comparison to the buy-and-hold market portfolio. Several factors motivate this study. First of all, empirical evidence addressing the effectiveness of market timing has been mixed. Furthermore, virtually all research on market timing examines data of the U.S. and other developed countries and is at least ten years old. Thus, the resulting empirical findings may not be readily applicable to emerging markets such as Taiwan or to the latest decade in which we have witnessed two catastrophic financial downturns with no significant relief to the second one in sight. In addition, most empirical work is performed on monthly returns, the usage of which has been documented as a plausible cause for the ambiguity surrounding market timing studies. Also, a majority of empirical research in the field either focuses on the market timing ability of mutual funds or involves market timing strategies that require fund allocation among multiple asset classes or sectors or involve the use of complex or proprietary software and thus are not easy or economical for individual investors to duplicate. Last but not least, most market timing studies examine the strategy’s effectiveness against a passive benchmark instead of comparing the performance of two active trading strategies with respect to each other.

In light of the observations noted above, this research studies daily security return data from February 1995 to December 2008 in Taiwan, an emerging financial market, for the performance evaluation of two active trading strategies in relation to each other and in comparison to a passive buy-and-hold strategy. This research makes significant contribution to finance literature because its empirical findings would provide more insight into the effectiveness of discount rate changes as a market timing indicator, the merit of market timing, and the superiority/inferiority of the two active trading strategies with respect to each other in terms of risk-return tradeoff. For robustness, the entire sample period is further divided into two subsample periods, pre-March 2000 and post-February 2000 periods, and six evaluation measures are employed for performance analysis and comparison purposes.

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The rest of the paper is organized as follows. Section 2 provides literature review. Section 3 covers data and methodology. Section 4 presents empirical findings. Section 5 concludes this study.

II. LITERATURE REVIEW

Significant relationship between monetary policy changes and stock returns in the U.S. and other developed countries are illustrated in [3] [9] [10] [22] [23] [34] [39]. The same conclusion is reached in [8] for the stock market in Taiwan. Justifiably, professionals often rely on monetary policy indicators such as discount rate changes, federal funds target, monetary aggregate, and reserve aggregate, to name a few, to guide their investment decisions. Notably, changes in discount rate are advocated by [28] to signal monetary policy. It cites three main reasons for discount rate changes to be favored as a signal for monetary policy. First, discount rate changes are perceived as a leading indicator for future monetary policy and economic development. Second, discount rate does not undergo changes frequently. This infrequency affords cost effectiveness for trading strategies guided by the indicator. Third, discount rate change’s binary (up and down) feature and well-publicized nature make the signal identification easy and unambiguous. Subsequently, [10] [20] [23] [25] [26] adopt the measure and categorize monetary environments accordingly as either expansive or restrictive. General consensus is that stocks produce higher return and exhibit lower return variability following discount rate decreases and turn the opposite upon rate increases.

Reference [21] suggests that monetary policy influences certain industries more greatly than other industries. In general, it finds that high beta stocks perform better than average following discount rate decreases while low beta stocks fare better than average following rate increases. Reference [10] documents that cyclical stocks possess much higher sensitivities to changes in monetary conditions than noncyclical stocks. Reference [11] further shows that cyclical stocks prosper during expansive monetary periods while noncyclical stocks prevail in restrictive monetary environments. Reference [4] promotes a sector rotation strategy that demands investment in the cyclical sectors during economic upswings and in the defensive sectors during economic downturns. Thus, monetary policy shifts signaled by discount rate changes should play a prominent role in sector-based portfolio rotation strategies.

Reference [13], however, finds that the well documented significant relationship between monetary policy and stock market in finance literature has vastly disappeared over the recent past for most of its 16 sample countries, including the U.S. Reference [2] reaches a similar conclusion. Reference [32] also cautions the practice of basing stock return explanation and forecast in various monetary conditions on monetary policy variables. Reference [14] further suggests that investors are unlikely to benefit from exploiting past or anticipated Federal Reserve decisions.

While market timing is a method frequently explored and examined as a potentially effective investment strategy to beat the market, empirical work has produced mixed results. References [1] [6] [12] [15] [17] [31] study mutual fund performance and find little evidence in support of fund managers’ market timing ability. In contrast, [29] concludes that fund managers possess superior ability to time the market. Reference [37], based on its observation and dissection of the Dow Jones Industrial Average from January 1946 to December 1991, claims that market timing outperforms buy and hold. However, no guidance is provided in the study for investors to effectively time the market. Reference [27] proposes a discrete regression model (DRM) and argues that market timers following the DRM can enhance their portfolio return by actively rotating their funds between cash and common stocks. Reference [35] finds that a market timing trading strategy guided by discount rate changes outperforms the benchmark market portfolio. In specific, the formulated market timing portfolio calls for a full investment in the market upon an initial discount rate cut and a complete pullout from the market with an exclusive holding of riskless assets instead upon an initial rate increase. Reference [38] illustrates the dominance of a market timing strategy via the use of a proprietary computerized model. Reference [11] shows that expansive monetary policy favors cyclical stocks and restrictive monetary policy benefits noncyclical stocks. It, in turn, proposes a sector rotation strategy and examines the efficiency of the strategy. Under the scheme, industry sectors are first classified into cyclical and noncyclical sectors based on their respective market betas. Investors following this active trading strategy then closely monitor the monetary policy and rotate their portfolio holdings accordingly between the two broad sectors. In essence, an initial discount rate cut signals an exit from the defensive sectors and a simultaneous entrance to the cyclical sectors while an initial discount rate increase prompts exactly the opposite. Empirical evidence derived from the study’s sample period of January 1973-December 2005 supports dominance of the sector rotation strategy over two passive strategies, including the buy and hold.

All studies cited above in support of market timing are performed on return data of the U.S. and other developed countries. Thus, the results may not be readily applicable to emerging markets such as Taiwan. This represents a void that merits attention. With the exception of [7] [11], test data examined in the existing studies in favor of market timing are at least 10 years old. For its latter subsample period of 1993-2004, [7] finds some weak evidence backing a simple buy-and-hold strategy. Reference [38] also fails to detect market timing ability over its last subsample period of 1993-1999. Therefore, it is necessary to reexamine the effectiveness of market timing by updating the data set, a point validated by [13] [14]. Using data covering time periods of 1986-2000 and 2001-June 2004, respectively, the two studies portend that Federal Reserve policy no longer bears relevance to stock returns. Reference [15] claims that most standard timing tests are misspecified and yield downward bias due to their usage of monthly instead of daily data. Reference [5] also shows that the timing skill of market timers can be masked when monthly data in lieu of daily data are used.
TABLE 1

<table>
<thead>
<tr>
<th>Series</th>
<th>Monetary Policy</th>
<th>Date</th>
<th>Discount Rate</th>
<th>Rate Change</th>
<th>Rate Change Sequence in Series</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Restrictive</td>
<td>02/01/1995</td>
<td>5.8</td>
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<td>1</td>
</tr>
<tr>
<td>2</td>
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<td>5.5</td>
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<td>3</td>
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<tr>
<td></td>
<td></td>
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<td>D</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>08/01/1996</td>
<td>5</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Restrictive</td>
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<td>I</td>
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<td>4</td>
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<td>D</td>
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</tr>
<tr>
<td></td>
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<td>12/01/1998</td>
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<td>D</td>
<td></td>
</tr>
<tr>
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<td>02/01/1999</td>
<td>4.5</td>
<td>D</td>
<td></td>
</tr>
<tr>
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<td>Restrictive</td>
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</tr>
<tr>
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<td></td>
<td>06/01/2000</td>
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</tr>
<tr>
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<td>03/06/2001</td>
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<td>D</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>03/30/2001</td>
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</tr>
<tr>
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<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>05/18/2001</td>
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<td>06/29/2001</td>
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<tr>
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<td>08/20/2001</td>
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<td>09/19/2001</td>
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<tr>
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<td>03/31/2006</td>
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<td>06/30/2006</td>
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<td>3.5</td>
<td>I</td>
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<tr>
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<td>8</td>
<td>Expansive</td>
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<tr>
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<td></td>
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<tr>
<td></td>
<td></td>
<td>12/12/2008</td>
<td>2</td>
<td>D</td>
<td></td>
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</tbody>
</table>

Notes: Discount rate information is retrieved from the Central Bank of China’s Web site, www.cbc.gov.tw. Over the full sample period from February 1995 to December 2008, the CBC has changed the discount rate 47 times—20 increases and 27 decreases. We define a rate series as a sequence of consecutive rate changes in the same direction. This results in eight rate-change series, four expansive monetary periods characterized by discount rate decreases and four restrictive monetary periods featured with discount rate increases.
This study examines the performance of two active trading strategies by using daily security return data prevailing in Taiwan from February 1995 to December 2008. Adopting the framework of [11] [35], we rely on discount rate changes implemented by the Central Bank of China in Taiwan (CBC hereafter) to guide both the standard market timing strategy and the sector rotation strategy. In this classification scheme, the absolute level of the discount rate does not carry much significance. Rather, it is the direction of the last rate change which signifies future monetary policy shift that matters. Thus, only rate-change series are relevant and considered. The CBC is assumed to be under the same monetary policy (expansive vs. restrictive) until a discount rate change in the opposite direction takes place. The period following a discount rate increase is classified as a restrictive environment; the period following a discount rate decrease is categorized as an expansive environment. The standard market timing portfolio consists of the market portfolio during periods of credit easing and is fully invested in riskless assets during periods of credit tightening. The sector rotation strategy entails investors switching their investment holdings between the cyclical sectors during expansive monetary policy periods and the noncyclical sectors during restrictive monetary policy periods. The benchmark buy-and-hold strategy calls for the investment in and continued holding of the market portfolio throughout the entire sample period. Thus, returns of the buy-and-hold strategy over the sample period are equal to concurrent market returns.

Discount rate, risk-free instrument rate, and stock market index are needed for the implementation of the standard market timing strategy. Treasury bills are undoubtedly the ideal proxy for the risk-free investment vehicle when its rate information is available. Otherwise, secondary market of repurchase agreements on 31-90-day government bonds or Commercial First Bank one-month time deposit is used to proxy the risk-free asset. The Taiwan Stock Exchange composite index (TWSE), a value-weighted index, serves as the proxy for the market portfolio in this study. For the sector rotation strategy, we rely on 19 Taiwan industry indices (Automobile, Cement, Chemicals, Construction, Electric and Machinery, Electrical Appliance Cable, Electronics, Finance, Foods, Glass and Ceramics, Others, Paper and Pulp, Plastics, Rubber, Steel and Iron, Textiles, Tourism, Transportation, and Wholesale and Retail). Discount rate information is retrieved from the CBC’s Web site at www.cbc.gov.tw. Data for the risk-free rate, TWSE, and the industry indices are from the financial database of the Taiwan Economic Journal.

Table 1 lists key information related to the discount rate-change series. Following [21], this study removes the first two days of every rate-change series from the sample to avoid any announcement-period effect. The conservative approach minimizes the opportunity that investors may react to and capitalize on the announcement of a change in monetary policy. As the table shows, over the full sample period from February 1995 to December 2008, the CBC has changed the discount rate 47 times, 20 increases and 27 decreases, and yielded eight rate-change series, four expansive monetary periods characterized by discount rate decreases and four restrictive monetary periods featured with discount rate increases. The last rate-change series started on September 26, 2008 and was continuing at the onset of this research. Since both market timing strategies adopted in this study require portfolio reconstruction whenever a discount rate change reverses its direction, the two respectively, actively managed portfolios rebalance seven times in 14 years or every two years on average.

Before performing any statistical test to evaluate the two market timing strategies, a simple and preliminary analysis is conducted to determine if monetary policies categorized by the direction of discount rate changes as expansive (restrictive) effectively signal positive (negative) news for the capital market. We expect stock returns during monetary loosening periods to be on average higher than those during monetary tightening periods if discount rate changes serve as a useful barometer for monetary environments and thus, as a good signal for the implementation of the market timing strategies. In contrast, Treasury bills should in general yield more under a restrictive monetary policy than under an expansive monetary policy. Statistics presented next in Table 2 vastly support this contention and provide justification for the intuition of the two proposed market timing strategies.

Table 2 contains the respective number of days expansive and restrictive stances are in place and the associated annualized mean returns for Treasury bills and stock market over the entire sample period and the two subperiods. The stock

### TABLE 2

<table>
<thead>
<tr>
<th>Number of Days</th>
<th>T-bill Rate (%)</th>
<th>Stock Market Return (%)</th>
<th>Difference in Stock Market Return (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expansive Period</td>
<td>Restrictive Period</td>
<td>Expansive Period</td>
<td>Restrictive Period</td>
</tr>
<tr>
<td>2/1995-12/2008</td>
<td>1985</td>
<td>1630</td>
<td>3.43</td>
</tr>
<tr>
<td>3/2000-12/2008</td>
<td>990</td>
<td>1216</td>
<td>1.90</td>
</tr>
</tbody>
</table>

Notes: The table contains the number of days during which the monetary policy is expansive and restrictive, respectively, for the entire period and the two subperiods. Also reported are the annualized mean T-bill rate and mean stock market return under the two monetary policies for the three sample periods. The mean returns are annualized by compounding average daily returns by 250. Data for the risk-free rate and the stock market are retrieved from the financial database of the Taiwan Economic Journal. The two-sample t-test is conducted to investigate if the mean stock market return difference between the two monetary periods is statistically significant. The numbers in parentheses are the t-statistics.

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market consistently generates a higher mean return during expansive monetary periods than during restrictive monetary periods. The two-sample t-test is conducted to see if the mean stock market return difference between the two monetary periods is statistically significant. The reported t-test results indicate that the mean returns associated with the two monetary policies are significantly different from each other at the 1% significance level for the entire sample period and for the pre-March 2000 period. As projected, the mean T-bill rate is higher in the restrictive monetary environment than in the expansive monetary environment for both subperiods. The only notable exception resides in the T-bill rate for the entire sample period when its average associated with the expansive periods is greater than that pertaining to the restrictive periods. This disparity reflects CBC’s relatively aggressive take on rate decrease in the pre-2000, high-rate environment and its relatively aggressive pursuit of rate increase in the post-2000, low-rate environment.

In addition to the determination of an effective economic indicator, proper classification of industries to capture their sensitivities to the economic environment is essential to the implementation of the sector rotation strategy. Reference [4] specifies that the cyclical sectors are characterized by industries with above-average sensitivities to the state of the economy and thus above-average betas. The opposite holds true for the noncyclical sectors. We adopt this proposition and use beta, $\beta$, for the sector classification purpose. For each sample industry, the derivation of beta is based on the capital asset pricing model (CAPM) of [30] [36] and the regression expressed next:

$$R_t - R_{f,t} = \alpha + \beta(R_{m,t} - R_{f,t}) + \epsilon_t$$  \hspace{1cm} (1)

where $\alpha$ is the regression intercept term and $R_{f,t}$, $R_t - R_{f,t}$, $R_{m,t} - R_{f,t}$, and $\epsilon_t$ are risk-free rate, industry excess return, market excess return, and error term, respectively, for any given day $t$. Table 3 lists regression results in descending order of the betas derived for the 19 industries over the entire sample period. The equally-weighted beta across all 19 sample industries is 0.85. To ensure sufficient differentiation between cyclical and noncyclical sectors, we categorize industries with the two highest betas, Electronics and Electrical Appliance Cable, as cyclical, and industries with the two lowest betas, Wholesale and Retail and Tourism, as noncyclical. In sequence, the sector rotation portfolio is constructed by equally weighting the two cyclical industries during expansive monetary periods and the two noncyclical industries during restrictive monetary periods.

Motivated by lack of consensus on a generally accepted statistical method for performance evaluation, we adopt several measures in this study. The multiple-evaluation approach also allows the capitalization on measure-specific merits and guards against methodology related bias. For robustness check, the entire sample period is further divided into pre-March 2000 and post-February 2000 subperiods and performance tests are performed on both subperiods as well. In consideration of Haugen [18], five risk-adjusted indices—Jensen’s alpha [24], Treynor measure [40], Sharpe ratio [36], and the two Graham-Harvey measures, GH1 and GH2 [16]—are employed to account for and reflect on respective portfolio risk and performance. In addition, a two-beta regression model proposed by [19] [33] is adopted. For performance analysis and comparison purposes, all mean returns are annualized by compounding average daily returns by 250 and all standard deviations are annualized by multiplying the respective daily standard deviations by the square root of 250. A brief description for each undertaken performance evaluation method follows next.

### Jensen’s Alpha

Jensen’s alpha captures the performance of a portfolio under evaluation relative to the overall capital market, i.e. the market portfolio. Thus, it allows direct performance comparison between a market timing strategy and the buy-and-hold strategy. To derive the statistic, a linear

$$R_t - R_{f,t} = \alpha + \beta(R_{m,t} - R_{f,t}) + \epsilon_t$$

<table>
<thead>
<tr>
<th>Industry Index</th>
<th>Constant</th>
<th>Beta</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electronics</td>
<td>0.03</td>
<td>1.12</td>
<td>0.78</td>
</tr>
<tr>
<td>Electrical</td>
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<td>1.02</td>
<td>0.60</td>
</tr>
<tr>
<td>Appliance</td>
<td>-0.02</td>
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<td>0.69</td>
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<td>Finance</td>
<td>-0.01</td>
<td>0.94</td>
<td>0.61</td>
</tr>
<tr>
<td>Textiles</td>
<td>-0.02</td>
<td>0.91</td>
<td>0.43</td>
</tr>
<tr>
<td>Construction</td>
<td>0.01</td>
<td>0.91</td>
<td>0.49</td>
</tr>
<tr>
<td>Rubber</td>
<td>0.00</td>
<td>0.91</td>
<td>0.45</td>
</tr>
<tr>
<td>Cement</td>
<td>0.01</td>
<td>0.91</td>
<td>0.55</td>
</tr>
<tr>
<td>Plastics</td>
<td>0.01</td>
<td>0.87</td>
<td>0.48</td>
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<tr>
<td>Transportation</td>
<td>-0.00</td>
<td>0.87</td>
<td>0.43</td>
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<tr>
<td>Paper and Pulp</td>
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<td>0.86</td>
<td>0.43</td>
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<td>0.48</td>
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<td>Glass and Ceramics</td>
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<tr>
<td>Others</td>
<td>0.00</td>
<td>0.76</td>
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<tr>
<td>Steel and Iron</td>
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<td>Automobile</td>
<td>-0.01</td>
<td>0.71</td>
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<tr>
<td>Wholesale and Retail</td>
<td>0.00</td>
<td>0.70</td>
<td>0.39</td>
</tr>
<tr>
<td>Tourism</td>
<td>0.01</td>
<td>0.66</td>
<td>0.49</td>
</tr>
</tbody>
</table>

Note: Data for the industry indices are retrieved from the financial database of the Taiwan Economic Journal. The average beta across all 19 sample industries is 0.85. The $t$-statistics are in parentheses. The asterisks (*) and (**) denote statistical significance at the 10% and 1% significance levels, respectively.
regression in the form of Eq. (1) noted earlier is performed on the two market timing portfolios, respectively. In specific, for each market timing portfolio over the sample period, its return in excess of the risk-free rate is regressed on the market risk premium. \( \alpha \), the regression intercept term, is Jensen’s alpha. A positive \( \alpha \) indicates that the market timing portfolio should be preferred because it has, on average, generated a higher return than the buy-and-hold portfolio. The opposite favors the passive buy-and-hold strategy.

**Treynor Measure**

Treynor measure, \( T_p \), is a reward-to-risk measure that shows the risk premium earned per unit of market risk. Eq. (2) illustrates the calculation of the ratio by dividing the average excess return of a portfolio by its market risk.

\[
T_p = \frac{(R_p - R_f)}{\beta_p} \tag{2}
\]

where \( R_p - R_f \) and \( \beta_p \) are the portfolio’s average excess return and market risk, respectively. Beta of the buy-and-hold strategy, by design, equals to one. For each market timing strategy, beta is estimated by running Jensen’s alpha regression illustrated in Eq. (1). The trading strategy yielding the highest \( T_p \) is the most dominating one.

**Sharpe Ratio**

Even though market risk is the only risk that investors should be compensated for, total risk or standard deviation is what investors bear and thus what matters in performance evaluation. This calls for total risk-adjusted return measures such as Sharpe ratio. As displayed in Eq. (3), Sharpe ratio, \( S_p \), is a reward-to-risk ratio that captures the risk premium earned per unit of total risk and is derived by dividing the average excess return of a portfolio by the standard deviation of its returns.

\[
S_p = \frac{(R_p - R_f)}{\sigma_p} \tag{3}
\]

where \( \sigma_p \) is the standard deviation of the portfolio’s returns. The trading strategy associated with the highest \( S_p \) is the most outperforming one.

**Graham-Harvey Measures**

Reference [16] recognizes the fact that the investment with the highest Sharpe ratio does not necessarily carry a risk desired by investors. As a result, it proposes another two risk-adjusted performance measures that, like the Jensen’s alpha, allow a direct return comparison between paired investments and therefore, unambiguously identifies the optimal portfolio for any desired risk level.

The two Graham-Harvey measures, \( GH1 \) and \( GH2 \), are similar to each other by design. Both involve matching the total risks of the portfolios under comparison. The two measures differ in the choice as to which portfolio’s total risk is the one to match with. To illustrate, assume that the two portfolios under comparison are an active market timing portfolio and the passive buy-and-hold portfolio.

For \( GH1 \), it is the volatility of the market timing portfolio that we intend to match with. This entails levering up or down the buy-and-hold (i.e. market) portfolio by investing \( \sigma_p/\sigma_m \) in the market portfolio and the remaining \( (1-\sigma_p/\sigma_m) \) in risk-free securities. The resulting \( GH1 \), as shown and simplified in Eq. (4), is then calculated as the mean return difference between the market timing portfolio and the levered buy-and-hold portfolio.

\[
GH1 = R_p - \left[ \frac{\sigma_p}{\sigma_m} R_m + (1 - \frac{\sigma_p}{\sigma_m}) R_f \right] = R_p - \left[ R_f + (\frac{\sigma_p}{\sigma_m})(R_m - R_f) \right] \tag{4}
\]

A positive (negative) \( GH1 \) indicates the outperformance (underperformance) of the market timing strategy relative to the buy-and-hold strategy.

For \( GH2 \), the volatility of the buy-and-hold portfolio is the basis for the risk match. This, in turn, requires leveraging or unleveraging the market timing portfolio by investing \( \sigma_m/\sigma_p \) in the actively managed portfolio and the remaining \( (1-\sigma_m/\sigma_p) \) in risk-free securities. This practice leads to the derivation and simplification of \( GH2 \) in Eq. (5), where the mean return of the buy-and-hold portfolio is subtracted from the mean return of the levered (unlevered) market timing portfolio.

\[
GH2 = \frac{\sigma_m}{\sigma_p} R_p - \left( \frac{\sigma_m}{\sigma_p} R_m + (1 - \frac{\sigma_m}{\sigma_p}) R_f \right) - R_m = \left[ R_f + (\frac{\sigma_m}{\sigma_p})(R_p - R_f) \right] - R_m \tag{5}
\]

As with \( GH1 \), a positive (negative) \( GH2 \) reveals the superiority (inferiority) of the market timing strategy relative to the buy-and-hold strategy.

**Two-beta Regression Model**

In order to distinguish market timing ability from skills that are not market timing related, a two-beta (up-market beta and down-market beta) regression model proposed by [19] [33] is also adopted in this study. Skilled market timers in response to anticipated market upturns (downturns) would adjust and shift their portfolios to high (low) risk securities. High-risk securities are, in general, more responsive to market movements than low-risk securities. Therefore, portfolio beta in up markets, up-market beta, should be greater than that in down markets, down-market beta. Equation (6) expresses the two-beta regression model.

\[
R_{p,t} - R_{f,t} = \alpha_t + \beta_1(R_{m,t} - R_{f,t}) + \beta_2\text{Max}(0,(R_{m,t} - R_{f,t})) + e_{p,t} \tag{6}
\]

where \( R_{p,t} - R_{f,t} \) and \( R_{m,t} - R_{f,t} \) are daily excess returns of the market timing portfolio and the buy-and-hold portfolio, respectively, \( \alpha_t \) is the intercept term, and \( e_{p,t} \) is the error term. Eq. (6) can be simplified into Eq. (7) when the market is up and \( R_{m,t} \) presumably is greater than \( R_{f,t} \).

\[
R_{p,t} - R_{f,t} = \alpha_t + \beta_1(R_{m,t} - R_{f,t}) + e_{p,t} \tag{7}
\]
where $\beta_1$ is the up-market beta. Eq. (6) would transform into Eq. (8) when the market is down and $R_{mc}$ presumably is less than $R_{f,t}$.

$$R_{p,t} - R_{f,t} = \alpha_1 + (\beta_1 - \beta_2)(R_{mc,t} - R_{f,t}) + \epsilon_{p,t}$$ (8)

where $(\beta_1 - \beta_2)$ is the down-market beta, and $\beta_2$ measures the change in the beta when market timers respond to an anticipated market downturn by effectively lowering the risk exposure of their portfolios. Thus, a significantly positive $\beta_2$ indicates effective market timing.

Test results displayed in Table 4 over the entire study period provide strong support for the two market timing strategies. All five risk-adjusted performance measures, with the exception of insignificantly positive Jensen’s alpha, $\alpha$, associated with the sector rotation, suggests the outperformance of the two actively managed portfolios over the benchmark market portfolio. Jensen’s alpha, $\alpha$, for the standard market timing portfolio is significantly positive at the 1% significance level, indicating its superiority to the passive buy-and-hold market portfolio. The slope coefficient, $\beta$, lies between zero and one for both active trading strategies. This is consistent with the expectation of lower

### TABLE 4

| Regression for Jensen's Alpha | | |
|---|---|---|---|
| | Time Period | $\alpha$ | $\beta$ | $R^2$ |
| Standard Market Timing | 2/1995-12/2008 | 0.03 (2.65)** | 0.58 (71.01)** | 0.58 |
| | 2/1995-2/2000 | 0.03 (3.10)** | 0.69 (55.97)** | 0.69 |
| Sector Rotation | 3/2000-12/2008 | 0.02 (1.02) | 0.53 (49.80) | 0.53 |
| | 2/1995-12/2008 | 0.03 (1.63) | 0.92 (88.99) | 0.92 |
| | 2/1995-2/2000 | 0.03 (1.38) | 0.95 (63.73)** | 0.74 |
| | 3/2000-12/2008 | 0.02 (1.03) | 0.90 (65.42)** | 0.66 |
| Time Period | | | | |
| | Standard Market Timing | | | |
| | 2/1995-12/2008 | 9.57 | 0.30 |
| | 2/1995-2/2000 | 25.66 | 0.94 |
| | 3/2000-12/2008 | -2.51 | -0.07 |
| Sector Rotation | 2/1995-12/2008 | 1.71 | 0.06 |
| | 2/1995-2/2000 | 11.63 | 0.44 |
| | 3/2000-12/2008 | -3.92 | -0.14 |
| | 2/1995-12/2008 | -5.52 | -0.22 |
| | 2/1995-2/2000 | 2.96 | 0.13 |
| | 3/2000-12/2008 | -10.43 | -0.40 |
| Time Period | | | | |
| | 2/1995-12/2008 | 9.78% | 12.28% |
| | 2/1995-2/2000 | 15.21% | 18.35% |
| | 3/2000-12/2008 | 6.26% | 8.60% |
| Sector Rotation vs. Buy-and-Hold | 2/1995-12/2008 | 7.71% | 6.94% |
| | 2/1995-2/2000 | 7.81% | 7.06% |
| | 3/2000-12/2008 | 7.69% | 6.90% |
| | Standard Market Timing vs. Sector Rotation | | | |
| | 2/1995-12/2008 | 4.49% | 6.54% |
| | 2/1995-2/2000 | 9.36% | 12.49% |
| | 3/2000-12/2008 | 1.24% | 1.89% |

Notes: Performance measures cover the entire sample period and the two subsample periods of pre-March 2000 and post-February 2000. Jensen’s alpha is the intercept term derived from regressing the risk premium of the market timing portfolio on the market risk premium. A significantly positive $\alpha$ suggests superior market timing ability. Treynor measure is a reward-to-risk measure that shows the risk premium earned per unit of market risk. Sharpe ratio is a reward-to-risk ratio that captures the risk premium earned per unit of total risk. To illustrate the two Graham-Harvey measures, $GH1$ and $GH2$, assume that the two portfolios under comparison are an active market timing portfolio and the passive buy-and-hold portfolio. $GH1$ captures the mean return difference between the two portfolios after the buy-and-hold portfolio is levered up or down to match the resulting risk with that of the market timing portfolio. A positive (negative) $GH1$ indicates the outperformance (underperformance) of the market timing strategy relative to the buy-and-hold strategy. $GH2$ reflects the mean return difference between the two portfolios after the market timing portfolio is leveraged or unleveraged to match the resulting risk with that of the buy-and-hold portfolio. As with $GH1$, a positive (negative) $GH2$ reveals the superiority (inferiority) of the market timing strategy with respect to the buy-and-hold strategy. The asterisk ** denotes statistical significance at the 1% significance level.

### IV. EMPIRICAL RESULTS

Table 4 reports statistics derived from the five risk-adjusted evaluation methods employed in this study—Jensen’s alpha, Treynor measure, Sharpe ratio, and the two Graham-Harvey measures, $GH1$ and $GH2$. The two active, market timing trading strategies—standard market timing and sector rotation—and the passive buy-and-hold strategy are compared with one another. To investigate if the performance pattern persists over time, the entire sample period is further divided into two subsample periods, pre-March 2000 and post-February 2000 eras. Evaluation outcomes for the subsample periods as well as for the entire study period are contained in Table 4.

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risk for the two market timing portfolios than for the buy-and-hold portfolio due to the significant amount of time market timers take defensive stance. The respective coefficients of determination, 58% and 69%, suggest that the regression model represents a good fit for the data. Both Treynor measure and Sharpe ratio are higher for the two market timing portfolios than for the passive benchmark. As a matter of fact, both statistics for the buy-and-hold portfolio are negative. Thus, investors holding the market portfolio from February 1995 to December 2008 would have incurred a negative return. The positive Graham-Harvey measures, \( \text{GH1} \) and \( \text{GH2} \), derived for the respective comparison of the two market timing strategies with the passive buy-and-hold further favor the two active trading strategies.

Table 4 also documents the standard market timing’s dominance over the sector rotation for the full sample period. Jensen’s alpha, \( \alpha \), suggests that the standard market timing strategy yields significantly higher-than-market return. The same conclusion cannot be drawn for the sector rotation strategy. The standard market timing portfolio possesses more positive Treynor measure and Sharpe ratio and thus, provides better risk-return tradeoff than the sector rotation portfolio. Similarly, the positive Graham-Harvey measures, \( \text{GH1} \) and \( \text{GH2} \), generated for the evaluation of the two active trading strategies relative to each other indicate that when risk is held constant, the standard market timing produces higher return than the sector rotation.

Evaluation results reported in Table 4 for the pre-March 2000 era are virtually the same as those for the entire sample period. With the exception of the positive but insignificant Jensen’s alpha, \( \alpha \), associated with the sector rotation strategy, all evaluation indicators lend strong support for the two active trading strategies. The significantly positive Jensen’s alpha, \( \alpha \), for the standard market timing strategy signifies its superior performance in comparison to the buy-and-hold strategy. The fact that both Treynor measure and Sharpe ratio are higher for the two market timing strategies than for the buy-and-hold strategy further suggests that market timing produces better risk-return tradeoff than buy and hold. The same conclusion can also be drawn from the positive Graham-Harvey measures.

When the two active trading strategies are compared with each other for the pre-March 2000 period, the standard market timing once again prevails, reaching the same conclusion as that for the full sample period. Jensen’s alpha, \( \alpha \), for the standard market timing over the subperiod is significantly positive. Thus, unlike the sector rotation, the simple market timing strategy delivers a significantly higher risk-adjusted return than the market as a whole during the pre-March 2000 period. The standard market timing portfolio’s dominance over the sector rotation portfolio for the period is also substantiated by the fact that its Treynor measure and Sharpe ratio are more positive than their counterparts for the sector rotation portfolio. Moreover, both Graham-Harvey measures, \( \text{GH1} \) and \( \text{GH2} \), generated for the evaluation of the two active trading strategies relative to each other are positive. This further shows that holding risk constant, the standard market timing delivers higher return than the sector rotation.

Test results covered in Tables 4 for the post-February 2000 period basically reach the same conclusion as that for the entire sample period and the pre-March 2000 period and are in favor of the two active trading strategies over the passive buy and hold. However, the supporting evidence is not as strong as that documented for the other two periods. Although Jensen’s alpha, \( \alpha \), is positive for both market timing strategies, neither is statistically significant. This suggests that investors following either market timing strategy for the latter subsample period gain minimal edge over buy-and-hold investors. While all the other four risk-adjusted evaluation methods point to the superiority of the two market timing portfolios to the benchmark market portfolio, the dominance, as evidenced in the consistently less negative Treynor measure and Sharpe ratio, resides on loss reduction rather than wealth accumulation. Hence, investors pursuing either of the two active trading strategies would have incurred less loss than investors following the passive buy-and-hold strategy. Similarly, the positive \( \text{GH1} \) and \( \text{GH2} \) reflect the respective loss that investors would have evaded if they had adopted the two active market timing strategies in lieu of the passive buy-and-hold strategy while matching the risk between the active and passive strategies.

Between the two active trading strategies, empirical evidence presented in the table for the post-February 2000 period clearly favors the standard market timing, an observation noted earlier for the other two test periods. While Jensen’s alpha, \( \alpha \), fails to differentiate the two market timing strategies due to the two alphas’ statistical insignificance, the other four risk-adjusted measures unanimously support the standard market timing approach. Even though both strategies yield negative Treynor measure and Sharpe ratio, they are less negative for the standard market timing approach. This suggests that investors adopting the standard market timing strategy would have incurred less loss per unit risk wise than those employing the sector rotation strategy. The positive Graham-Harvey measures, \( \text{GH1} \) and \( \text{GH2} \), derived for the comparison of the two active trading strategies further confirm that investors exposed to the same level of risk would be better off by following the standard market timing strategy than taking on the sector rotation strategy. Given negative Treynor measure and Sharpe ratio associated with both strategies, the positive \( \text{GH1} \) and \( \text{GH2} \) depict how much loss investors could have avoided if they had practiced the standard market timing strategy and stayed away from the sector rotation strategy.

In short, empirical results contained in Table 4 clearly show that the standard market timing is the most dominating strategy. While Jensen’s alpha suggests a diminishing dominance of the strategy over the latter subperiod, it should not come as a surprise. References [2] [13] [14] [32] document disconnection between monetary policy variables and security returns when fairly recent data are used. Reference [7] in its study of seven developed countries finds empirical evidence against the standard market timing strategy, albeit weak, over the period of January 1994-August 2004. Nonetheless, given overwhelming support over the entire sample period and the former subsample period, and strong backing over the latter subsample period for the standard market timing strategy, investors should consider adopting this strategy to optimize their risk-return tradeoff. In contrast, empirical results indicate that the passive buy-and-hold is the least effective strategy. Among the three alternative trading strategies,
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investors passively holding the market portfolio would incur the least gain over the pre-March 2000 era and would suffer the most loss during the post-February 2000 period, per unit risk wise.

To further validate the supremacy of the standard market timing strategy, the two-beta regression proposed by [19] [33] is performed. In the two-regression model expressed in Eq. (8), $\beta_1$ is the up-market beta and $(\beta_1 - \beta_2)$ is the down-market beta. By design, the beta difference between the up and down markets is captured by $\beta_2$. A significantly positive $\beta_2$ suggests effective market timing. The two-beta regression results exhibited in Table 5 lend additional support for the standard market timing strategy. The positive and statistically significant $\beta_2$ in Table 5 for the strategy over all three test periods shows that market timers following the strategy are persistently effective at anticipating market movement and adjusting risk accordingly. The displayed empirical findings also suggest that discount rate changes function effectively as a market timing indicator and market timers should take it into consideration when formulating their investment strategies. In contrast, empirical evidence presented in the table paints a different picture for the sector rotation strategy. Investors following the strategy fail to effectively adjust their portfolio risk exposure in response to anticipated market conditions. Over the three sample periods, $\beta_2$ associated with the sector rotation strategy is consistently negative. The negative coefficient is statistically significant at the 5% significance level for the full sample period, portending the sector rotation portfolio’s higher possession of risk during market downturns than during market upturns. In summary, empirical results presented in Table 5 clearly favor the standard market timing strategy and disfavor the sector rotation strategy.

V. CONCLUSION

This study uses daily financial return data from February 1995 to December 2008 in Taiwan to evaluate the performance of two market timing strategies—standard market timing and sector rotation—and a passive buy-and-hold strategy. The two market timing strategies are guided by the discount rate changes. The standard market timing strategy calls for full investment in the market portfolio in a rate declining environment and in risky securities in a rate rising environment. The sector rotation strategy involves shifting investment into the sector of cyclical industries during expansive monetary periods and switching the fund to the sector of noncyclical industries during restrictive monetary periods. The buy-and-hold strategy entails constant holdings of the market portfolio. Six statistical measures are employed for performance comparison and evaluation purposes.

Empirical evidence derived from the six analytical methods provides strong, uniform support for the superiority of the standard market timing strategy over the entire sample period. When the full study period is divided into pre-March 2000 and post-February 2000 subsample periods, two observations stand out. First, the standard market timing strategy outperforms the other two strategies in both subsample periods even though its dominance has weakened somewhat over time. Second, while the standard market timing strategy, compared with the buy-and-hold strategy, allows investors to accumulate significantly more wealth in the pre-March 2000 era, the strategy has transformed its supremacy to the form of a passive investment tool in emerging markets even though some investors. Thus, market timing may still be a worthwhile effectiveness in implementing the strategy by individual investors. Nonetheless, despite the unprecedented financial meltdown and uncharted territory, the standard market timing strategy has fared remarkably well. This is encouraging especially in consideration of the ease and cost effectiveness in implementing the strategy by individual investors. Thus, market timing may still be a worthwhile investment tool in emerging markets even though some empirical evidence in recent finance literature suggests that the strategy might have lost its steam in developed countries.

\[
R_{p,t} - R_{f,t} = \alpha_t + \beta_1 (R_{m,t} - R_{f,t}) + \beta_2 \max(0, -(R_{m,t} - R_{f,t})) + \epsilon_{p,t}
\]

### Table 5: Two-Beta Regression Model

<table>
<thead>
<tr>
<th>Time Period</th>
<th>$\alpha_t$</th>
<th>$\beta_1$</th>
<th>$\beta_2$</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Market Timing</td>
<td>-0.04 (-2.00)**</td>
<td>0.65 (43.83)**</td>
<td>0.13 (5.31)**</td>
<td>0.59</td>
</tr>
<tr>
<td>2/1995-2/2000</td>
<td>-0.00 (-0.12)</td>
<td>0.74 (33.70)**</td>
<td>0.11 (3.04)**</td>
<td>0.69</td>
</tr>
<tr>
<td>3/2000-12/2008</td>
<td>-0.06 (-2.34)**</td>
<td>0.60 (31.08)**</td>
<td>0.13 (4.23)**</td>
<td>0.53</td>
</tr>
<tr>
<td>Sector Rotation</td>
<td>0.06 (2.66)**</td>
<td>0.89 (47.46)**</td>
<td>-0.06 (-2.11)**</td>
<td>0.69</td>
</tr>
<tr>
<td>2/1995-2/2000</td>
<td>0.06 (2.00)**</td>
<td>0.92 (34.20)**</td>
<td>-0.06 (-1.45)</td>
<td>0.74</td>
</tr>
<tr>
<td>3/2000-12/2008</td>
<td>0.06 (1.89)**</td>
<td>0.87 (34.70)**</td>
<td>-0.07 (-1.63)</td>
<td>0.66</td>
</tr>
</tbody>
</table>

Notes: In the model, the dependent variable is the risk premium of the market timing portfolio and the independent variables are the market risk premium and a variable that equals to the maximum of zero and the negative amount of the market risk premium. By design, the beta difference between the up and down markets is captured by $\beta_2$. A significantly positive $\beta_2$ is perceived as favorable evidence for the market timing strategy. The asterisks ‘*’, ‘**’, and ‘***’ denote statistical significance at the 10%, 5%, and 1% significance levels, respectively.

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The study also illustrates that discount rate changes function effectively as a market timing indicator. Therefore, market timers should pay close attention to the monetary policy set by the Central Bank of China in Taiwan. While empirical results in general support the superiority of the sector rotation strategy to the passive buy-and-hold strategy, the strategy does not provide the same promise as the standard market timing. Transaction costs and scarcity of sector ETFs and mutual funds in Taiwan cast further doubt on sector rotation as a viable market timing strategy.

REFERENCES


THE RISK-TAKING BEHAVIOR OF A STOCKHOLDER-OWNED LIFE INSURANCE
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ABSTRACT

Prior research has not been well examined the firm-level and country-level corporate governance to risk-taking behavior. Data focus on 471 life insurance companies in 13 EU countries from 1995 to 2006. We prove that life insurers’ risk-taking behavior increases with firm-level corporate governance, further examine the interaction effect between the firm-level and country-level to risk-taking behavior respectively. Our argument is the same as the Dodge, Karolyi and Stulz (2007), under more free economic freedom countries, life insurers with high firm-level corporate governance has more opportunities to take risk. However, the result is mixed depending on various indexes of country-level governance.

Keywords: Financial Risk Assessment, Insurance, Corporate governance, Economic Freedom, Risk-taking Behavior

INTRODUCTION

Since the sub-prime mortgage crisis happened, the international market tumble was consequent on the bankruptcy of Lehman Brothers in September 2008. Under the financial tsunami, bank and insurance industry also got involved. For example, American International Group Inc. (AIG) endures the liquidity crisis when its credit ratings were downgraded below "A-" levels in September 2008. Unlike other industries, insurance industry has developed a number of complex products and at the same time has to reduce the profit loadings in these products to compete in the marketplace [8]. In response, they undertake the public interest and loss. As long as the financial difficulty bursts out, the effect is the most serious and far-flung than all financial institutions. Especially for the bankruptcy of insurers, they have more significant costs. Overall, the financial storm induces us to review the risk-taking behavior of life insurers.

While most studies suggest that the main factors to risk-taking behavior include ownership structure (e.g. [19] [36] [8] [7]), CEO negation power (e.g. [16] [1]) and board composition [13]. Based on the agency theory, managers have competing agency relationships with shareholders and policyholders. In the modes of governance of stockholder-owned life insurance, shareholders direct financial flows within the company away from policyholders and towards themselves, especially large shareholders, can utilize more pressure over managers than small disparate policyholders. In addition, while shareholders can diversify their risk in capital market, managers often attempts to change firm risk by investment a lot projects. For their own private benefits, managers may be conservative and avoid taking risks in investments, including value-enhancing ones [18], especially for they only receive fixed salaries, they would not acquire additional reward as who compensated with shares and share option [30]. However, [34] [8] [7] advanced by is the wealth transfer hypothesis versus risk aversion hypothesis, they argue that if managers enlarge the proportion of ownership, their behavior and interest will align with shareholders’ interests and have strong motivation to maximize theirs’ value by increase the level of risk. In the case of life insurance companies, shareholders always own significant cash flow rights or votes. Insiders are pressured into taking risk for shareholders’ interests. Shareholders have more incentives and power to avoid being expropriated by managers. [2] find that mainly in East Asian firms, multiple shareholders structures exert an internal governance role to control private benefits and to reduce information asymmetry, they actively take risks in investments. Overall, we propose high shareholder independence degree leads insurers to engage in high level of risk taking behavior.

Numerous researches use chief executive officer (CEO) duality to proxy corporate governance. [31] refers to the [13] [36] [17] and documents bank risk-taking behavior is positively related to strong board while negatively related to CEOs power. However, [37] show that CEOs with the dual role as a chairman of the board has a negatively impact on the firm’s risk strategy. In the life insurance industries, CEOs is likely to be the person with the most power and influence within the company. If CEOs are part of the board, they often exploit theirs’ power and negotiate with their board of directors to seize some private benefit, furthermore, they have more power to make risk taking behavior decision [1]. So CEOs duality is an important factor to affect risk taking behavior making.

Regarding the determinant of corporate board have found that board size (e.g. [4] [16] [20] [9]), shareholders concentration [25] and board independence (e.g. [13] [16]).

1 Stock and mutual are the two major ownership structures in the insurance industry. In the case of stock companies, shareholders as principals who employ managers to act as their agents in the running of the company, policyholders to act as their agents in the management of risk and the provision of financial intermediary serviced. The mutual companies, policyholders and shareholders are the same, the mutual insurance companies which are not exposed to the market for corporate control. However, in the European insurance industries, the mutual structure in many countries mainly focuses on the different kinds of insurance (e.g. mutual life insurance company has significant market share in United Kingdom; mutual property-liability insurance company has mainly been engaged in France; in Germany, life and property-liability insurance have been played an equally important role). The mutual structure of life insurance companies is more difficult to examine the risk-taking behavior in the European insurance industries, so we examine for a sample of stockholder owned life insurance companies in the European.

2 Advanced by risk aversion hypothesis, Smith and Stulz (1985) affirm that if the ownership shares of managers’ increases they become increasingly risk averse and are more likely to purge hedging and other risk reducing strategies. It implies that even managers realize engaging excessive risk taking would increase the market value of owner’s equity, they only care about the their long run compensation. The optimal long run compensation depends on the survival of insurance firms. Therefore, they become increasingly risk averse when as the ownership share of manager’s increases.

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Among these variables, board size is the most closely related to several firm operating and industry characteristics. [4] indicate the three hypotheses: scope of operations hypothesis, monitoring hypothesis and negotiation hypothesis are important to the firm attributes. 3 [36] suggest that a small level of board size allows for effectively monitoring and improves firm performance. [20] also indicates that larger boards face the problem of coordination and director free-riding, they could be less effectively than smaller boards. Although with twofold arguments of board size, we prefers to the first view is scope of operations hypothesis, because stockholder-owned life insurance companies generally have many different kinds of insurance policy, they can diversification risk and have ability to make more risky investment decision. Overall, we use the internal governance mechanism (shareholder ownership, CEOs and board size) to be the firm-level corporate governance, arguments hypothesis one can be stated as:

**H1: Other things equal, higher firm-level corporate governance leads life insurers to engage in higher level of risk taking behavior.**

Insurance industry is a risk intermediary, they have a lot of complex products in different financial markets spread over the world. Insurers are more extremely regulated to prevent from any systematic risk and to protect the interest of policyholders. The country-level legal protection can facilitate better monitoring of financial activities including theirs’ risk-taking behavior. [5] argues that insurance industry have bilateral informational asymmetries characteristic, the regulation can prevent the adverse affects of information asymmetries for illiquid contracts. Furthermore, regulation can be a protection mechanism to guarantee insurers commit to their contracts. In addition, [14] [24] [30] claim the importance of regulation in banks. About the proxy of country-level legal, [22] refers to the [25] and use the investor protection index to examine the relationship between corporate governance and risk-taking. However, several authors [29] criticize the investor protection proxy with conceptual ambiguities. Therefore, we follow [10], p.441 for using anti-self-dealing index to be my control variable and to express the legal protection of minority shareholders against expropriation by corporate insiders. In sum, corporate governance varies widely across countries and across firms. [12] find that country characteristics explain much more of the variance in governance rating than observable firm characteristics. It is important to examine the corporate governance to affect risk-taking behavior by country characteristics of governance.

Economic freedom is a part of country characteristics of governance. The level of economic freedom differs from one country to another, it has been developed and used in their productive abilities, exchange goods and services with others, compete in markets, and keep the fruits of their labor [15]. In generally, high index of economic freedom, it is means that the country’s regulation is the freest. As shown in Figure 1 form the Heritage Foundation Index of Economic Freedom, it shows that after year 2001, the index of Europe started to exceed the index of Americas. So it is important to understand that how to affect life insurance companies risk-taking behavior decision in the freest country. Therefore, the influence of economic freedom in Europe should be taken into considered.

(Insert Figure 1 about here)

**H2: Other things equal, the country-level of corporate governance by economic freedom is positively correlated with life insurers’ risk-taking if the firm-level corporate governance is higher.**

Several financial structure variables that are likely to affect risk-taking behavior are also included as control variables. The insurance specific variables including size, consolidated, leverage and reinsurance are also considered. There have competing hypotheses are relate to the size, the bankruptcy cost of small firms is greater than larger firms from the financial distress viewpoint. However, [22] tabulate a significantly negative relation between risk-taking behavior in banking industry, So the effect of size is indeterminate. In addition, in view of the consolidated firm have more resource and capital; consolidated insurers have more possibility to take more risky decision. Furthermore, in life insurance industry, the policyholders with the fixed long-term claims act as the bondholders. High leverage increases costly contracting. The residual claimants increase their value of claim for diminishing the outstanding debt. Higher leverage life insurers have higher probability to face

---

3 The first hypothesis implies that board structure is driven by the scope and complexity of the firm’s operations (Fama and Jensen, 1983 and Coles, Daniel and Naveen, 2008). The second hypothesis implies that degree of information asymmetry and the size monitoring cost determine the board size (Demsetz and Lehn, 1985; Raheja, 2005). The third hypothesis implies that board composition results from a negotiation between CEO and firm’s outside board members (Hermalin and Weisbach, 1998).
underinvestment problem. Therefore, negative relation between risk-taking and leverage is expected. Then, an insurer may also rely on the reinsurance and involves in the risky behavior. Even the use of reinsurance can be a sign that the insurers have more tendencies to avoid risks.

We believe that this study contributes to broaden literatures on the following ways. First, prior literature (e.g. [22]) has used the insurer protection to proxy country-level corporate governance and has empirically examined the relationship between corporate governance and risk-taking. However, the investor protection proxy they have with conceptual ambiguities, we follow [11] and use the completeness of anti-self-dealing index to be my control variable and to express the legal protection of minority shareholders against expropriation by corporate insiders. Second, few studies directly investigate the relationship between corporate governance and risk-taking behavior in the insurance industry. [2] show that life insurers’ risk-taking behavior increases with managerial ownership. However, the paper only considers one aspect of corporate governance. In this study, we use a number of measures to characterize each life insurers’ corporate governance. Third, with regard to the corporate governance and risk-taking behavior, especially in the European life insurance industry, the research literature is very limited. Because the data of European life insurance is difficult to get, we get the data which relate to life insurers’ financial statements from the Eurothys database, moreover, through the ISIS database to get the insurance financial information. Fourth, we further examine the country-level corporate country-level corporate and argue that stockholder-owned life insurance in high economic freedom countries has more opportunities to take risk, the argument consist with the same as the [12]. Lastly, to our knowledge, literature has documented that risk-taking behavior is a determinant of firm-level corporate governance. However, the country-level corporate governance country-level corporate has not been well examined and empirical evidence varies. Moreover, no prior research has examined the interaction between country-level and firm-level corporate governance to risk-taking behavior respectively.

Two prior studies that are closely connected to ours include [6]. However, several major differences exist. They focus on the determinants of the board structure for property-liability insurers and managerial ownership for US life insurance industry respectively. However, the board structure and managerial ownership are considered as only part of corporate governance. Furthermore, both studies all have not considered the country characteristics of governance. Therefore, we use data from life insurers and include completely characteristics of firm-level governance; furthermore, we examine the interaction between country-level and firm-level corporate governance within cross country data to gauge the relationship.

**THE METHODOLOGY AND EMPIRICAL FRAMEWORK**

As discussed above, we examine the relationship between corporate governance and risk-taking behavior, and then investigate the interaction effect of different levels of economic freedom on the relationship of corporate governance and risk-taking behavior. We therefore construct these equations as follows:

\[
\text{Risk}_{ij,t} = \beta_0 + \beta_1 \text{Board size}_{i,t} + \beta_2 \text{CEOs duality}_{i,t} + \beta_3 \text{Shareholder independence degree}_{i,t} + \beta_4 \text{Economic freedom}_{i,t} + \epsilon_{i,t},
\]

(1)

\[
\text{Risk}_{2ij,t} = \beta_0 + \beta_1 \text{Board size}_{i,t} + \beta_2 \text{CEOs duality}_{i,t} + \beta_3 \text{Shareholder independence degree}_{i,t} + \beta_4 \text{Economic freedom}_{i,t} + \beta_5 \text{CV}_{i,t} + \epsilon_{i,t},
\]

(2)

Where \( \text{Risk}_{ij,t} \) denotes the earnings volatility of life insurer \( i \) in year \( t \), we follow John, Litov and Yeund (2008) to compute it to represent the firm-level and country-level risk-taking behavior respectively. \( \text{Board size}_{i,t} \), CEOs duality \( i,t \) and Shareholder independence degree \( i,t \) are the firm-level of corporate governance mechanism in the life insurance industry. Economic freedom \( i,t \) is the economic freedom index of life insurer \( i \) in year \( t \), it represents the country characteristics of governance mechanism. Furthermore, we examine the interaction effect by the eight dimensions of economic freedom: Economic Freedom (ECFR), Business Freedom (BUFR), Fiscal Freedom (FCFR), Government Size (GOSI), Monetary Freedom (MOFR), Investment Freedom (INF), Financial Freedom (FIFR) and Labor Freedom (LAFR). \( \text{CV}_{ij,t} \) and \( \text{CV}_{2ij,t} \) are two different sets of control variables which can be identified effect the firm-level and country-level risk-taking behavior. \( \epsilon_{i,t} \) and \( \epsilon_{2i,t} \) are the error term.

**Data description and diagnostics**

We mainly use the Eurothys and ISIS database to retrieve the data for all variables which used in this research. The Eurothys include financial statements of insurers in 76 countries all over the world. The ISIS database can reveal detail insurance financial information: audit, shareholder ownership, manager’s name etc. all over the world. The study employs an unbalanced sample of yearly-based panel database of 471 stockholder-owned life insurance companies in 13 European Union (EU) countries. Table 1 presents the number of sample and economic freedom index in every country.

(Insert Table 1 about here)

**Measure of variables**

\[4 \text{ Some EU countries are excluded. For instance, Cyprus, Czech, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovak Republic, and Slovenia are excluded because their life insurers’ information cannot be retrieve from our data sets. In addition, Ireland and Luxembourg are also excluded for lack of legal protection indices on the research of La Porta et al. (1998).} \]
We expect that corporate governance influence risk taking behavior. We first examine the corporate governance and risk-taking, and then investigate the interaction effect of different levels of economic freedom on the relationship of corporate governance and risk-taking. Prior research suggests a number of factors which may affect the relation between corporate governance and risk-taking. These factors in both equations are examined as follows and a list of variables and their definitions are described in Table 2.

(Insert Table 2 about here)

The measure of Risk-taking, adopting risky investment behavior leads to have more volatile returns on capital, we follow [22, p.1687-1993] and utilize two proxies for the degree of risk-taking in firms’ operations based on the volatility of corporate earnings: (i) the market-adjusted volatility of firm level earnings over the sample period from 1995 to 2006; (ii) a country average of the volatility of firm earnings. To calculate risk 1, we gather each firm’s earnings before income tax and total asset data from Eurotaxis. We keep the company if they provide more than six years EBIT and total asset data over the 1995 to 2006 period. First, we divide EBIT by total asset each year. Second, we average all the EBIT / Total Asset ratio. Then, the average is subtracted by each year’s EBIT / Total Asset ratio. Finally, the calculated deviations of each firm would have one standard deviation. This standard deviation is viewed as the firm-level risk. Thus, every company has a specific risk value regardless the year. Risk 2 is the country-level risk, we use the average Risk 1 in every country to express Risk 2.

The measures of explanatory variables, we inspired by the concept of [31, p.1340-1343] and [25, p.1145-1150], the corporate governance is gauged by shareholder independence degree, CEOs duality, and board size. [25] collected data on 10 largest nonfinancial firms in 49 countries and computed the combined (cash flow) ownership stake of its three largest shareholders. First, according to the definition of ISIS database, the independence indicator categorizes companies into four groups: A means no shareholders recorded with more than 25% direct or total ownership. That is, A represents the independent companies. B is attached to any company with a known recorded shareholder, none of which with an ownership percentage over 50%, but having one or more shareholders with an ownership percentage above 25%. C means no shareholders recorded with more than 50% direct ownership. One shareholder recorded with more than 50% total ownership. That is, these companies can be viewed as indirectly majority owned firms. While the companies which classified into D is the directly majority owned. One shareholder recorded with more than 50% direct ownership. We transfer A, B, C, and D into 1, 2, 3, and 4.

About the measures of economic freedom, the index is published by the Heritage Foundation and available for each country since 1995. The Index of Economic Freedom is a simple average of 8 individual freedoms, each of which is vital to the development of personal and national prosperity. Each dimension has a score between 0 and 100 percent. The business freedom (ECFR) score for each country is a number between 0 and 100 percent. Fiscal freedom (FCFR) is composed of three quantitative components in equal measure: the top tax rate on individual income, the top tax rate on corporate income, and total tax revenue as a percentage of GDP. Scoring of the government size factor (GOSI) is based on government expenditures as a percentage of GDP. Monetary freedom (MOFR) score combines two components: the weighted average inflation rate for the most recent three years and price controls. Investment freedom (INFR) is an assessment of the free flow of capital, especially foreign capital. Index with 100 percent equals foreign investment (FI) is encouraged and treated the same as domestic investment, with a simple and transparent FI code and a professional, efficient bureaucracy. The financial freedom factor (FFIFR) measures the relative openness of each country’s banking and financial system. The authors score this factor by determining the extent of government regulation of financial services; the extent of state intervention in banks and other financial services; the difficulty of opening and operating financial services firms (for both domestic and foreign individuals); and government influence on the allocation of credit. The authors use this analysis to develop a description of the country’s financial climate and assign it an overall score between 0 percent and 100 percent. Labor freedom (LAFR) composites four quantitative components are equally weighted as 25 percent of the labor freedom factor: minimum wage, rigidity of hours, difficulty of firing redundant employees, and cost of firing redundant employees.

Anti-self-dealing is a revised estimate of the anti-director rights index which reveal from [25, p.1130, 1142]. The data based on their questionnaire received from 102 firms. [11, p.342] contend that anti-self-dealing index is ‘an index of the strength of minority shareholder protection against self-dealing by the controlling shareholder’. Anti-self-dealing is designed as the average of ex ante and ex post private control of self-dealing. In addition, the insurance-specific variables including size, leverage, and reinsurance are also considered. To measure firm size of the insurer is the natural logarithm of the insurer’s gross premiums written. We use the gross premiums written instead of total asset. From the financial distress viewpoint, the bankruptcy cost of small firms is greater than larger firms. The size is negatively related to risk-taking behavior. On the other hand, from the economics of scale viewpoint, the size is negatively related to risk-taking behavior. [22] tabulate a significantly negative relation between risk-taking behavior and the natural logarithm of initial corporate asset in banking industry. In addition, in life insurance industry, the policyholders with the fixed long-term claims act as the bondholders in other industry. High leverage increases costly contracting. The residual claimants increase their value of claim for diminishing the outstanding debt. Higher leverage life insurers have higher probability to face underinvestment problem. Therefore, negative relation between risk-taking and leverage is expected. In this study, we define leverage as total liability divided by surplus. Moreover, the measure of an insurer’s reinsurance activity is the ratio of reinsurance ceded to total direct premiums plus reinsurance assumed. Insurers diversify the risks through reinsurance, remaining the retention to be the consideration. An insurer may also rely on the reinsurance and involves in the risky behavior.
Even the use of reinsurance can be a sign that the insurers have more tendencies to avoid risks, in this study, we assume that reinsurance is positively relevant.

**EMPIRICAL RESULTS**

**Univariate analysis**

The sample is comprised of 471 stockholder-owned life insurance companies in 13 European Union (EU) countries during the period from 1995 to 2006. We separately present the summary statistics with regard for all variables in Table 3. In addition, we show a Pearson correlation coefficient matrix for all the variables, which indicates the strength and direction of the linear relationship between them. The results indicate that risk-taking behavior have a significant relation to all the firm-level corporate governance, further significant to the Anti-self-dealing index, firm size and reinsurance control variables. In addition, the variable of risk taking is significantly related to the relevant control variables. Moreover, all the coefficient values for all the control variables in this study are less than 0.5, and this indicates that there is no collinear relationship between them.

(Insert Table 3 about here)

**Multivariate analysis**

The relationship between firm-level corporate governance and risk-taking behavior, Table 4 presents OLS estimates of the determinants of the firm-level risk-taking. We first ensure that there are no collinear relationships within our analysis as all the calculated VIFs are smaller than 10. Then, we use the Breusch–Pagan (BP) test to test for heteroscedasticity in a linear regression models. Results of the heteroscedasticity by the BP test show that there is no conditional heteroscedasticity in all regression equations (calculated values: 4.5121, 5.2182, 5.8864 and 9.3421 are respectively smaller than \(\chi^2\) value 18.30704), means that the estimated variance of the residuals from a regression is dependent on the values of the independent variables. In addition, with regard to the autocorrelation problem use the Durbin – Watson (DW) statistic to detect whether the presence of autocorrelation is in the residuals from a regression analysis. There is statistical evidence that the error terms are not respectively auto correlated because all test statistic (\(d=1.89518, 1.9874, 1.9904\) and 1.9347) are bigger than upper critical values (\(d_{0.05,12}=1.87983\)). Lastly, in an effort to avoid endogeneity problem, we lagged values for all control variables. The importance of Board size, CEO duality and Shareholder’s ownership concentration leads to significant positive relationship with firm-level risk-taking. In addition, the positive relationship between Anti-self-dealing index and risk-taking behavior interprets that high barrier to self-dealing induce the investors to eliminate the fear of being expropriated. In our data sample, 72% firms are independent company. Leverage is negatively related to risk-taking behavior. In life insurance industry, the policyholders with the fixed long-term claims act as the bondholders in other industry. Higher Leverage life insurers have higher probability to face underinvestment problem. Therefore, the negative relation result is as expected. Reinsurance is negatively related to the risk-taking behavior.

The result may due to the use of Reinsurance is a sign that the insurers have more tendencies to avoid risks. Overall, the result shows that the life insurers’ risk-taking behavior is significantly and positively related to firm-level corporate governance.

(Insert Table 4 about here)

Furthermore, the interaction effect of economic freedom on the relationship between country-level risk-taking behavior and corporate governance in Table 5 by OLS. We sure that there are no collinear relationships within our analysis as all the calculated VIFs are smaller than 10. Then, results of the heteroscedasticity by the Breusch–Pagan (BP) test show that there is no conditional heteroscedasticity in all regression equations (calculated values: 17.6588, 18.0327, 17.6588 and 18.0327 are respectively smaller than \(\chi^2\) value 18.30704), means that the estimated variance of the residuals from a regression is dependent on the values of the independent variables. In addition, we found no autocorrelation problem within my model by Durbin – Watson (DW) statistic (\(d=4.8844, 5.9275, 4.1679\) and 5.9271 are bigger than upper critical values \(d_{0.05,12}=1.87983\)). Lastly, we lag values for all control variables. According to the result, the different of economic freedom affect the insurer’s risk-taking behavior decision. Country-level of corporate governance by economic freedom is positively correlated with life insurers’ risk-taking if the firm-level corporate governance is higher. Life insurance in high economic freedom countries has more opportunities to take risk. Board size, Shareholder independence degree and CEOs duality are statistically significant to economic freedom. It illustrates that, under the highest of BUFR, INFR, CIFR and MOFR economic freedom environment, the Board size, Shareholder ownership and CEOs duality has more positive impact on risk-taking behavior. However, the result is mixed depending on various indexes of country-level corporate governance. Board size, Shareholder independence degree and CEOs duality are all not statistically significant to the LAFR. In addition, Board size is also only not statistically significant to the ECFR; Shareholder independence degree and CEOs duality are also not statistically significant to the GOSI. In the closely-held companies, shareholders’ profit or lost is highly rely on the firm’s risk-taking behavior and performance. Although they expect abnormal return from risky investment, shareholders in closely-held company have more opportunities to suffer unsystematic risk. This result is also consistent with corporate bank evidence by [22].

With regards to Firm size, at the outset, we assume that firms affiliate with groups have more resource and investment opportunities to take risk. Large Firm size would lead managers to undertake risky behaviors in countries. The statistically significant positive coefficient on Firm size indicates that no matter the Leverage of economic freedom, the large firms have more preference to take risk for their abundant financial support and investment opportunities. With regards to Leverage and Reinsurance, as anticipated the coefficients on them are negative and statistically significant. The result conveys that an insurer may also rely on the Reinsurance and involves in the risky behavior. With respect to Anti-self-dealing index, as anticipated the coefficient on Anti-self-dealing index is positive across all
equations and statistically significant. This illustrates that better legal protection for shareholders, more obstacles the corporate insiders would face when converting corporate benefits back to themselves. With less fear of being expropriated by managers, shareholders would urge corporate insiders to take risky but value-enhancing investment. Overall, the findings support the notion that life insurance in high economic freedom countries positively affects the risk-taking behavior by well-firm-level corporate governance.

(Insert Table 5 about here)

CONCLUSIONS

The paper not only the firm-level corporate governance and risk taking behavior, but also examine the interaction effect between the firm-level and country-level to risk-taking behavior respectively. First, we prove that life insurers’ risk-taking behavior increases due to well-firm-level corporate governance. Life insurers’ risk-taking behavior increases with larger board size, high CEOs duality and shareholder independence degree. It implies that corporate governance which influenced by the Board size, Shareholder ownership concentration and CEOs duality is an important determinant of insurance risk-taking. Furthermore, we found the corporate governance proxies related to insurance risk-taking behavior consistent with the insurance contract environment. Given that better corporate governance is instrumental to insurance risk-taking, firms in high economic freedom countries have more opportunities to take risk. The argument is the same as the [12], stockholder-owned life insurance in high economic freedom countries has more opportunities to take risk. However, the result is mixed depending on various indexes of country-level corporate governance. In addition, large and have Reinsurance life insurance companies have ability to undertake risky behaviors. Furthermore, the result of coefficient on Leverage is significant negative to the risk-taking behavior; it is consist with my expectation. High Leverage increases costly contracting. The residual claimants increase their value of claim for diminishing the outstanding debt. Higher Leverage life insurers have higher probability to face underinvestment problem.

We recognize that findings in this paper are subject to several limitations. The data of European life insurance is difficult to get, we get the data which relate to life insurers’ financial statements from the Eurothesys database, moreover, through the ISIS database to get the insurance financial information. ISIS database provides the corporate governance information such as shareholder ownership, board composition and the name and position of board members at the latest disclosure date. The panel data like gross premium written and liability need to transfer into one specific value in one firm. We follow the method of John, Litov, and Yeung (2008, p.1688), take the average value to code variables.

REFERENCES


**FIGURE 1**

The average of worldwide economic freedom index

Notes: We refer the website (http://www.heritage.org/index) and the the book (Holmes, K. R., E. J. Feulner, and M. A. O'Grady, 2008, 2008 *Index of Economic Freedom*, The Wall Street Journal) to average the worldwide of individual economic freedoms respectively. The figure covers the period from 1995 to 2008, it further appears the tendency that the index of Europe started to exceed the index of Americas after year 2001. A majority of the freest economies are in Europe.
TABLE 1
Summary of all sample's economic freedom index

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<tbody>
<tr>
<td>Austria</td>
<td>27</td>
<td>70.0</td>
<td>80.6</td>
<td>86.0</td>
<td>51.2</td>
<td>25.3</td>
<td>81.4</td>
<td>70</td>
<td>70</td>
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<td>86.0</td>
<td>43.9</td>
<td>17.9</td>
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<td>90</td>
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<td>96</td>
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<td>90</td>
<td>90</td>
<td>90</td>
<td>86</td>
<td>80.7</td>
</tr>
</tbody>
</table>

Notes: We mainly use the Eurothesys and ISIS database to get my sample data. Eurothesys include financial statements of insurers in 76 countries all over the world; however, we only cover the period from 1995 to 2006 for the completeness of data. In addition, Due to data availability, we only include the EU countries that appear in La Porta et al. (1998, p.1124–1125, 1156). However, some EU countries are excluded (etc. Lithuania and Romania, Cyprus, Bulgaria, Malta, Slovak Republic and Slovenia) because their life insurers’ information cannot be retrieve from my data sets, for example: Bulgaria does not enforce the Directive 2002/83/EC. In addition, we use the anti-self-dealing index to be my one of control variables from the research of La Porta et al. (1998, p.1124–1125, 1156), Ireland and Luxembourg are excluded for lack the index. In sum, my study employs an unbalanced sample of yearly-based panel database of 471 life insurance companies in 13 EU countries. Furthermore, we refer the website (http://www.heritage.org/index) to appear the rank of countries of my data. In addition, we refer the research of La Porta et al. (1998, p.1124–1125, 1156) to choice the 10 individual freedoms which are relate to the investment activities around the cross country. Then, we average the 10 individual freedoms to be the index of Economic Freedom (ECFR).
<table>
<thead>
<tr>
<th>Variables</th>
<th>Expected sign</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Risk-taking Behavior</strong></td>
<td></td>
<td><strong>Risk 1</strong> We compute company earnings volatility.</td>
</tr>
<tr>
<td><strong>Risk 2</strong></td>
<td></td>
<td>It is a country-level risk-taking proxy. Defined as the average of the company risk-taking proxy RISK1.</td>
</tr>
<tr>
<td><strong>Firm-level Corporate Governance</strong></td>
<td></td>
<td><strong>Board size</strong> (+) We calculate only the number of directors on the board. The secretary or accountants on the board are eliminated. A dummy variable which is 1 if CEO duality takes place and 0 otherwise. In other words, CEOs DUALITY equals one if the CEO is also the chair of the board or if CEO is internally-hired.</td>
</tr>
<tr>
<td><strong>CEOs duality</strong></td>
<td>(+)</td>
<td>It represents the degree of shareholder independence. We apply a SHAREHOLDER INDEPENDENCE DEGREE of ISIS database. A represent the independent companies. D is the directly majority owned. One shareholder recorded with more than 50% direct ownership. We transfer A, B, C, and D into 1, 2, 3, and 4.</td>
</tr>
<tr>
<td><strong>Shareholder independence degree</strong></td>
<td>(+)</td>
<td></td>
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<tr>
<td><strong>Country-level Corporate Governance</strong></td>
<td></td>
<td><strong>Economic Freedom</strong> Annual Index of Economic Freedom that ranges from 100% to 0% with a higher percentage indicating less government control on financial institutions. This index is available for each country since 1995.</td>
</tr>
<tr>
<td><strong>Control variables</strong></td>
<td></td>
<td><strong>Anti-self-dealing index</strong> (+/-) It includes: (1) approval by disinterested shareholders; (2) disclosures by Buyer; (3) disclosures by Mr. James; (4) independent review; (5) each of the elements in the index of disclosure in periodic filings; (6) standing to sue; (7) rescission; (8) ease of holding Mr. James liable; (9) ease of holding the approving body liable; and (10) access to evidence.</td>
</tr>
<tr>
<td><strong>Firm size</strong></td>
<td>(+/-)</td>
<td>Defined as the natural logarithm of the insurer’s gross premium written.</td>
</tr>
<tr>
<td><strong>Leverage</strong></td>
<td>(-)</td>
<td>Defined as total liability divided by surplus.</td>
</tr>
<tr>
<td><strong>Reinsurance</strong></td>
<td>(-)</td>
<td>Ratio of Reinsurance ceded to total direct premium plus Reinsurance assumed.</td>
</tr>
</tbody>
</table>
TABLE 3
Descriptive statistics of all variables and correlation matrix

<table>
<thead>
<tr>
<th></th>
<th>Min</th>
<th>Max</th>
<th>Median</th>
<th>Mean</th>
<th>Q1</th>
<th>Q3</th>
<th>Std. Dev.</th>
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</thead>
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<tr>
<td><strong>Panel A: Descriptive statistic</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>RISK 1</td>
<td>0.00</td>
<td>58.39</td>
<td>0.01</td>
<td>110.26</td>
<td>0.00</td>
<td>0.01</td>
<td>2.97</td>
</tr>
<tr>
<td>RISK 2</td>
<td>0.01</td>
<td>1.72</td>
<td>0.01</td>
<td>110.14</td>
<td>0.01</td>
<td>0.02</td>
<td>0.31</td>
</tr>
<tr>
<td>Board size</td>
<td>0.00</td>
<td>66.00</td>
<td>4.00</td>
<td>115.38</td>
<td>2.00</td>
<td>8.00</td>
<td>4.39</td>
</tr>
<tr>
<td>CEOs duality</td>
<td>0.00</td>
<td>1.00</td>
<td>1.00</td>
<td>110.44</td>
<td>0.00</td>
<td>1.00</td>
<td>0.48</td>
</tr>
<tr>
<td>Shareholder independence degree</td>
<td>1.00</td>
<td>4.00</td>
<td>4.00</td>
<td>113.40</td>
<td>4.00</td>
<td>4.00</td>
<td>0.67</td>
</tr>
<tr>
<td>Anti-self-dealing index</td>
<td>0.27</td>
<td>0.59</td>
<td>0.27</td>
<td>0.31</td>
<td>0.27</td>
<td>0.33</td>
<td>0.07</td>
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<tr>
<td>Firm size</td>
<td>2.86</td>
<td>15.37</td>
<td>5.16</td>
<td>17.39</td>
<td>4.36</td>
<td>10.64</td>
<td>2.89</td>
</tr>
<tr>
<td>Leverage</td>
<td>-432.31</td>
<td>4988.34</td>
<td>13.70</td>
<td>105.61</td>
<td>8.72</td>
<td>28.49</td>
<td>231.65</td>
</tr>
<tr>
<td>Reinsurance</td>
<td>-0.19</td>
<td>88143.00</td>
<td>0.04</td>
<td>682.77</td>
<td>0.01</td>
<td>0.13</td>
<td>4347.78</td>
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<td><strong>Panel B: Correlation matrix</strong></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>(a)</th>
<th>(b)</th>
<th>(c)</th>
<th>(d)</th>
<th>(e)</th>
<th>(f)</th>
<th>(g)</th>
<th>(h)</th>
<th>(i)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) RISK1</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>(b) RISK 2</td>
<td>0.001**</td>
<td>---</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) Board size</td>
<td>-0.051**</td>
<td>-0.033***</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) CEOs duality</td>
<td>-0.082**</td>
<td>-0.123***</td>
<td>-0.146***</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(e) Shareholder independence degree</td>
<td>-0.068**</td>
<td>-0.084***</td>
<td>-0.065**</td>
<td>-0.119*</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(f) Anti-self-dealing index</td>
<td>-0.251**</td>
<td>-0.127**</td>
<td>-0.013***</td>
<td>-0.138**</td>
<td>-0.110**</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(g) Firm size</td>
<td>-0.091*</td>
<td>-0.239***</td>
<td>-0.078**</td>
<td>-0.068**</td>
<td>-0.134</td>
<td>-0.244***</td>
<td>---</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(h) Leverage</td>
<td>-0.011</td>
<td>-0.035</td>
<td>-0.034</td>
<td>-0.058</td>
<td>-0.011</td>
<td>-0.018*</td>
<td>-0.026*</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>(i) Reinsurance</td>
<td>-0.017*</td>
<td>-0.048*</td>
<td>-0.052**</td>
<td>-0.078**</td>
<td>-0.032</td>
<td>-0.118***</td>
<td>-0.115**</td>
<td>-0.033**</td>
<td>---</td>
</tr>
</tbody>
</table>

Notes: Panel A separately reports the descriptive statistics for all independent variables by showing minimum (Min.), maximum (Max.), median (Median), mean (Mean), first quartile (Q1), third quartile (Q3), and standard deviation (Std. Dev.). Panel B reports the pair wise of the Pearson correlation matrix for all variables. ***, **, and * represent statistical significance at the 0.01, 0.05, and 0.1 levels, respectively.
### Table 4
Firm-level risk-taking behavior and corporate governance

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-2.0896**(1.8985)</td>
<td>-2.1647**(1.8643)</td>
<td>-2.1433**(1.8729)</td>
<td>-2.0679**(1.8191)</td>
</tr>
<tr>
<td>Board size</td>
<td>-0.0016**(0.0498)</td>
<td>0.0021**(0.0431)</td>
<td>-0.0024**(0.0378)</td>
<td>0.0016**(0.0263)</td>
</tr>
<tr>
<td>CEOs duality</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shareholder</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>independence</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>degree</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anti-self-dealing</td>
<td>-5.9234** (0.0297)</td>
<td>-6.1235** (0.0364)</td>
<td>-7.1243** (0.0386)</td>
<td>-5.8792** (0.0676)</td>
</tr>
<tr>
<td>index</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firm size</td>
<td>(0.0195** (0.0347)</td>
<td>0.0378** (0.0245)</td>
<td>(0.0436** (0.0361)</td>
<td>(0.0249** (0.0288)</td>
</tr>
<tr>
<td>Leverage</td>
<td>-0.0033** (0.0691)</td>
<td>--0.0025** (0.0861)</td>
<td>-0.0027** (0.0874)</td>
<td>-0.0029** (0.0244)</td>
</tr>
<tr>
<td>Reinsurance</td>
<td>-0.0015** (0.7417)</td>
<td>--0.0016** (0.7389)</td>
<td>-0.0015** (0.7510)</td>
<td>-0.0015** (0.6094)</td>
</tr>
<tr>
<td>Number of observations</td>
<td>471</td>
<td>471</td>
<td>471</td>
<td>471</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.2348</td>
<td>-0.2454</td>
<td>-0.2458</td>
<td>-0.2774</td>
</tr>
<tr>
<td>F-statistic</td>
<td>(3.7352***</td>
<td>(-3.7843***</td>
<td>(-3.7755***</td>
<td>(-3.8411***</td>
</tr>
<tr>
<td>(p-value)</td>
<td>0.0021</td>
<td>0.0025</td>
<td>0.0023</td>
<td>0.0048</td>
</tr>
<tr>
<td>DW Test – Autocorrelation</td>
<td>1.8958</td>
<td>-1.9874</td>
<td>-1.9874</td>
<td>1.9347</td>
</tr>
<tr>
<td>Breusch - Pagan chi-squared– Heteroskedasticity</td>
<td>4.5121</td>
<td>5.2182</td>
<td>5.2182</td>
<td>9.3421</td>
</tr>
</tbody>
</table>

Note: The table presents the results of the ordinary least squares (OLS) estimates of firm-level risk-taking behavior. The numbers in the parentheses and brackets are standard errors and p-values, respectively. Within our analysis, we use the variance inflation factor (VIF) to quantify the multicollinearity within all regressions, it provide no collinearity relationship because all calculated VIFs are smaller than 10. Then, we use the Breusch–Pagan (BP) test to test for heteroscedasticity in a linear regression models. Results of the heteroscedasticity by the BP test show that there is no conditional heteroscedasticity in all regression equations (calculated values: 4.5121, 5.2182, 5.8864 and 9.3421 are respectively smaller than value 18.30704), means that the estimated variance of the residuals from a regression is dependent on the values of the independent variables. In addition, we use the Durbin – Watson (DW) statistic to detect whether the presence of autocorrelation is in the residuals from a regression analysis. There is statistical evidence that the error terms are not respectively auto correlated because all test statistic (d=1.89518, 1.9874, 1.9904 and 1.9347) are bigger than upper critical values (dU,a=1.87983). Lastly, we lagged values for all control variables are utilized as suggested by Greene (1997) and Kennedy (1998). ***, **, and * represent statistical significance at the 0.01, 0.05, and 0.1 levels, respectively.
<table>
<thead>
<tr>
<th>Independent variable</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>6.9373*** (7.0718)</td>
<td>7.7279*** (8.0581)</td>
<td>8.0943** (8.0247)</td>
<td>11.3113*** (9.0169)</td>
</tr>
<tr>
<td>Board size</td>
<td>1.0001*** (0.0008)</td>
<td>2.9832*** (0.0035)</td>
<td>1.3329*** (0.0033)</td>
<td>4.1804*** (0.0051)</td>
</tr>
<tr>
<td>Board size* ECFR</td>
<td>1.0033*** (0.0007)</td>
<td>3.2555*** (0.0077)</td>
<td>2.0203*** (0.0044)</td>
<td>3.1583*** (0.0057)</td>
</tr>
<tr>
<td>Board size* BUFR</td>
<td>3.2555*** (0.0077)</td>
<td>2.0203*** (0.0044)</td>
<td>3.1583*** (0.0057)</td>
<td>2.1563*** (0.0048)</td>
</tr>
<tr>
<td>Board size*FCFR</td>
<td>2.3337*** (0.0057)</td>
<td>2.1563*** (0.0048)</td>
<td>3.1583*** (0.0057)</td>
<td>3.9443*** (0.0086)</td>
</tr>
<tr>
<td>Board size*GOSI</td>
<td>2.3337*** (0.0057)</td>
<td>2.1563*** (0.0048)</td>
<td>3.1583*** (0.0057)</td>
<td>3.2325*** (0.0062)</td>
</tr>
<tr>
<td>Board size* MOFR</td>
<td>2.1563*** (0.0048)</td>
<td>3.9443*** (0.0086)</td>
<td>4.1452*** (0.0027)</td>
<td>3.8456*** (0.0751)</td>
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<tr>
<td>Board size*INFHR</td>
<td>1.0846*** (0.0036)</td>
<td>4.1346*** (0.0347)</td>
<td>2.1116*** (0.0147)</td>
<td>1.0755*** (0.0014)</td>
</tr>
<tr>
<td>Board size* FIFR</td>
<td>3.8456*** (0.0751)</td>
<td>1.1075*** (0.0014)</td>
<td>2.1116*** (0.0147)</td>
<td>1.0755*** (0.0014)</td>
</tr>
<tr>
<td>CEOs duality</td>
<td>5.4349*** (0.0077)</td>
<td>0.8917*** (0.0169)</td>
<td>6.4957*** (0.0069)</td>
<td>1.2206*** (0.0154)</td>
</tr>
<tr>
<td>CEOs duality * ECFR</td>
<td>2.5342*** (0.0096)</td>
<td>4.3104*** (0.0308)</td>
<td>4.1346*** (0.0347)</td>
<td>2.5342*** (0.0096)</td>
</tr>
<tr>
<td>CEOs duality * BUFR</td>
<td>2.5342*** (0.0096)</td>
<td>4.3104*** (0.0308)</td>
<td>4.1346*** (0.0347)</td>
<td>2.5342*** (0.0096)</td>
</tr>
<tr>
<td>CEOs duality * FCFR</td>
<td>2.1254*** (0.0033)</td>
<td>3.5431*** (0.0207)</td>
<td>4.1346*** (0.0347)</td>
<td>2.1254*** (0.0033)</td>
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<td>CEOs duality * GOSI</td>
<td>1.2055*** (0.0019)</td>
<td>2.0535*** (0.0191)</td>
<td>4.1346*** (0.0347)</td>
<td>1.2055*** (0.0019)</td>
</tr>
<tr>
<td>CEOs duality * MOFR</td>
<td>4.2833*** (0.0063)</td>
<td>5.2146*** (0.0613)</td>
<td>4.1346*** (0.0347)</td>
<td>4.2833*** (0.0063)</td>
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<tr>
<td>CEOs duality * INFR</td>
<td>5.3667*** (0.0071)</td>
<td>7.1035*** (0.0704)</td>
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<td>5.3667*** (0.0071)</td>
</tr>
<tr>
<td>CEOs duality * FIFR</td>
<td>4.5842*** (0.0068)</td>
<td>5.8813*** (0.0626)</td>
<td>4.1346*** (0.0347)</td>
<td>4.5842*** (0.0068)</td>
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<tr>
<td>CEOs duality * LAFR</td>
<td>1.4199*** (0.0025)</td>
<td>1.9989*** (0.0169)</td>
<td>4.1346*** (0.0347)</td>
<td>1.4199*** (0.0025)</td>
</tr>
<tr>
<td>Shareholder indep.</td>
<td>5.4455*** (0.0077)</td>
<td>6.4957*** (0.0069)</td>
<td>4.1346*** (0.0347)</td>
<td>5.4455*** (0.0077)</td>
</tr>
<tr>
<td>Shareholder indep. * ECFR</td>
<td>1.2206*** (0.0154)</td>
<td>2.8501*** (0.0424)</td>
<td>6.4957*** (0.0069)</td>
<td>1.2206*** (0.0154)</td>
</tr>
<tr>
<td>Shareholder indep. * BUFR</td>
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<td>2.7913*** (0.0453)</td>
<td>2.8501*** (0.0424)</td>
<td>2.0561*** (0.0474)</td>
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<tr>
<td>Shareholder indep. * FCFR</td>
<td>5.3154*** (0.0503)</td>
<td>5.9833*** (0.0760)</td>
<td>2.7913*** (0.0453)</td>
<td>5.3154*** (0.0503)</td>
</tr>
<tr>
<td>Shareholder indep. * GOSI</td>
<td>1.4597*** (0.0366)</td>
<td>1.5124*** (0.0382)</td>
<td>5.9833*** (0.0760)</td>
<td>1.4597*** (0.0366)</td>
</tr>
<tr>
<td>Shareholder indep. * MOFR</td>
<td>1.4107*** (0.0343)</td>
<td>1.1249*** (0.0169)</td>
<td>1.5124*** (0.0382)</td>
<td>1.4107*** (0.0343)</td>
</tr>
<tr>
<td>Shareholder indep. * INFR</td>
<td>5.9833*** (0.0618)</td>
<td>7.8692*** (0.0881)</td>
<td>1.1249*** (0.0169)</td>
<td>5.9833*** (0.0618)</td>
</tr>
<tr>
<td>Shareholder indep. * FIFR</td>
<td>5.5478*** (0.0572)</td>
<td>5.3165*** (0.0505)</td>
<td>7.8692*** (0.0881)</td>
<td>5.5478*** (0.0572)</td>
</tr>
<tr>
<td>Shareholder indep. * LAFR</td>
<td>3.8238*** (0.0531)</td>
<td>3.9897*** (0.0566)</td>
<td>5.3165*** (0.0505)</td>
<td>3.8238*** (0.0531)</td>
</tr>
<tr>
<td>Shareholder indep. * ECFR<em>UFR</em>FCFR<em>GOSI</em>MOFR<em>INFR</em>FIFR*LAFR</td>
<td>1.2604*** (0.0334)</td>
<td>1.4367*** (0.0328)</td>
<td>3.9897*** (0.0566)</td>
<td>1.2604*** (0.0334)</td>
</tr>
</tbody>
</table>

Dependent variable = Country-level risk-taking, **RISK 2**
### TABLE 5
(Continued)

<table>
<thead>
<tr>
<th></th>
<th>Number of observations</th>
<th>Adjusted $R^2$</th>
<th>$F$ test</th>
<th>DW Test – Autocorrelation</th>
<th>Breusch - Pagan chi-squared – Heteroskedasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anti-self-dealing index</strong></td>
<td>471</td>
<td>0.0347</td>
<td>13.7391***</td>
<td>4.8844</td>
<td>17.6588</td>
</tr>
<tr>
<td><strong>Firm size</strong></td>
<td>471</td>
<td>0.0489</td>
<td>15.6854***</td>
<td>5.9275</td>
<td>18.0327</td>
</tr>
<tr>
<td><strong>Leverage</strong></td>
<td>471</td>
<td>0.0461</td>
<td>16.3117***</td>
<td>4.1679</td>
<td>17.6588</td>
</tr>
<tr>
<td><strong>Reinsurance</strong></td>
<td>471</td>
<td>0.0529</td>
<td>21.1705***</td>
<td>5.9271</td>
<td>18.0327</td>
</tr>
</tbody>
</table>

Note: The table presents the results of the ordinary least squares (OLS) estimates of firm-level risk-taking behavior. The numbers in the parentheses and brackets are standard errors and p-values, respectively. Within our analysis, we use the variance inflation factor (VIF) to quantify the multicollinearity within all regressions, it provide no collinearity relationship because all calculated VIFs are smaller than 10. Then, we use the Breusch–Pagan (BP) test to test for heteroscedasticity in a linear regression models. Results of the heteroscedasticity by the BP test show that there is no conditional heteroscedasticity in all regression equations (calculated values: 17.6588, 18.0327, 18.0327 and 18.0327 are respectively smaller than value 18.30704), means that the estimated variance of the residuals from a regression is dependent on the values of the independent variables. In addition, we use the Durbin–Watson (DW) statistic to detect whether the presence of autocorrelation is in the residuals from a regression analysis. There is statistical evidence that the error terms are not respectively auto correlated because all test statistic (d=4.8844, 5.9275, 4.1679 and 5.9271) are bigger than upper critical values (dU,α =1.87983). Lastly, we lagged values for all control variables are utilized as suggested by Greene (1997) and Kennedy (1998). ***, **, and * represent statistical significance at the 0.01, 0.05, and 0.1 levels, respectively.
THE IMPACT OF NEWS ON STOCK MARKET: QUANTIFYING THE CONTENT OF INTERNET-BASED FINANCIAL NEWS

Xiqian Zhao, Juan Yang, Lili Zhao and Qing Li
Southwestern University of Finance & Economics, Chengdu, P.R. China
liq_t@swufe.edu.cn

ABSTRACT

In this article, we propose an approach to quantify the content of financial news and investigate its impact on the Chinese stock market. Our three main findings are: (1) Internet-based financial news tends to have a negative impact on the movements of Chinese stock market; (2) Firms with Shenzhen Stock Exchange are more affected by the Internet-based financial news than those of Shanghai Stock Exchange; (3) The impact of news on stock market is essentially determined by their contents. With these findings, we believe that Internet-based financial news contains hard-to-quantify information of firms, which investors could incorporate into stock prices timely.

Keywords: financial news, stock market, quantified language, text mining.

INTRODUCTION

The movements of stock market are determined by enormous factors including overall economy, inflation, trading strategies, return on equity (ROE), market sentiment, and firm itself. Intuitively, news articles reporting the fundamentals of firms or economics should affect the stock market to some degree. The impact of quantitative information on stock market prices has been studied by voluminous literature. Although quantitative data has been successfully applied to stock market forecast, there are evidences that substantial stock market movements do not seem to correspond to the changes in quantitative measures of firms' fundamentals[1]. This indeed suggests qualitative variables could be considered to complement quantitative measures to fully assess firm valuation. In particular, the linguistic descriptions of firms, especially online news articles, capture some aspects of firms' fundamentals. Such linguistic information could be utilized to overcome the incompleteness or biased measures of firms' fundamentals of analyst and publicly disclosed accounting variables.

With the advent of Web techniques, the Internet-based news media becomes a major vehicle to discover and disseminate the information. The timely and broad dissemination mechanism essentially makes it a potentially important source of information about firms' fundamental values. However, few researchers have studied the impact of news articles on stock prices, let alone the Internet-based news. This is partially because of the difficulty of transferring qualitative information into numerical data for further econometric analysis. When studying the connection between news and stock market, previous studies limit on the number or title of news articles. Some researchers go even further by utilizing the number of positive and negative words in the news. We argue that such crude quantitative measures could not fully reflect the linguistic power on firms’ fundamental values. In this article, we propose a sophisticated measure, i.e. support vector regression (SVR), to quantify the Internet-based News, and explore its impact on the daily returns of the relevant stocks. Here, we are particularly interested in 1) the concrete evidence to demonstrate the interaction between the Internet-based financial news and their relevant firms in Chinese stock market; 2) which kind of firm is more sensitive to the online news; 3) which type of financial news is more influential. The rest of this work is organized as follows. We first briefly describe relevant studies and background techniques in the next section. Then we present the design details for analyzing the impact of the Internet-based news articles in Chinese stock market. In the following part, we conduct experimental studies. At last, this article is concluded with speculation on how the current work can be further improved.

LITERATURE REVIEW

Since Keynes brought up the concept of “animal spirits” in 1930's, a large number of researchers are trying to understand the determinants of wild movements in stock market prices. Observing the fluctuation of stock prices accompanied by the news publishing, researchers have devoted substantial attention to explore the power of verbal information on stock market. The earliest research can be traced back to the work of Niederhoffer[2]. It was the first report that the movements of stock market are influenced by the news related with world events in the New York Times. Keown and Pinkerton[3] study the change of stock returns caused by the release of news on firm acquisition. Mitchell and Mulherin[4] point out that the number of Dow Jones announcements has a direct impact on several kinds of securities market activities including trading volume and market returns. These earlier findings reveal the connection of news and movements of stock markets.

Later on, more endeavors are devoted to finding out the influential patterns of news on stock market. For example, Cutler et al.[5] find out that one-third of variance in stock returns is brought by the news articles. Chan[6] examines the monthly stock returns of firms affected by the headlines of news containing these firms. This study shows that bad news reports result in a negative drift of the stock market up to 12 months. Fang and Peress[7] study the connections between the average stock return of certain firms and their media coverage in a period, and find out there is a significant return premium on stock with no media coverage. Tetlock[1][8] use news articles from the Wall Street Journal to measure the interaction between the media and the stock market. He finds the high media pessimism predicts downward pressure on
market prices followed by a reversion to fundamentals, and unusually high or low pessimism predicts high market trading volume. Takeda and Yamazaki [9] take a further step by studying the relations between the stock price of a firm and the exposure of a firm in a NHK TV program. One interesting finding of this study is that a simple report of a firm’s old story still has a potentially positive impact on its stock price. All of these studies reveal that the release of news reports on a firm tends to affect its stock market price to a certain degree. These researches focus on understanding the power of linguistic information on stock market. However, the way to quantifying the news articles in these studies is rather crude. Existing techniques can be categorized into two sub-groups. One is counting the times that a firm is mentioned in the headline or news body. The other is counting the words carrying the tone information (bad or good words) in news articles related with a particular firm. Such simple methods only partially capture firm fundamentals revealed in the news, and consequently weaken or distort the impact of news on stock market analysis.

To overcome this problem, computer scientists apply text mining and machine learning techniques to quantify verbal information and predict its impact on stock prices. Since Fledman and Dagan [10] combine the Knowledge Discovery in Databases (KDD) and text categorization paradigms, a large number of economists have devoted substantial attention to exploring the power of textual information on stock market. For instance, Withrich et al.[11] predict stock movement using textual information contained in news articles published on the Web. Several techniques, such as rule-based, k-NN algorithm and neural network, have been employed to produce the forecasts. Antweiler and Frank [12] extract messages from the Yahoo! Finance (YF) and Raging Bull (RB). They utilize Naïve Bayes and Support Vector Machine algorithms to code the individual message as bullish, bearish, or neither, and then find that stock messages can help predict market volatility. Schumaker and Chen [13] examine the role of financial news articles on three different textual representations: Bag of Words, Noun Phrases, and Named Entities and analyze their ability to predict stock prices twenty minutes after an article release. Lagreid and Sandal [14] employ text mining techniques to create a framework that enables extraction of entities (companies, people and other concepts) from Web-based business news.

However, they ignore the influence of the other key stock performance indicators, such as earning-to-price, share turnover, and price-to-equity on the stock market. These quantitative variables can complement qualitative measures to fully assess firm valuation. And it is rare to find the research about the relationship between news articles and stock market in China.

In this paper, we are dedicated to investigating the relation between Internet financial news articles and the stock returns in Chinese stock market, which considers both the linguistic information and quantitative variables. However, the detail of the proposed methodology is described in the next section.

DETAILS OF METHODOLOGY DESIGN

In this section, we describe the details of our methodology design to quantify the content of Internet-based financial news and the method to analyze its impact on Chinese stock market. First, we briefly introduce the data sets for our analysis. We then present the way to quantify the content of online news. Last, we describe our econometric analysis method for studying the impact of news on stock market.

Data

Chinese stock market consists of two parts, Shanghai and Shenzhen Stock Exchange. We select 85 firms related with information technology from both stock exchanges. The timeframe to analyze the movements of stock market is between August 1, 2010 and September 30, 2010. The volatility of the market index within this period is relatively stable so that we can avoid the wild influence of economic fluctuation. To explore the impact of online financial news on stock market, we construct two data sets. One is the stock trading data, and the other is a synthetic data set containing the Internet-based financial news articles related with the above 85 selected firms. Details of the data sets are:

(1) Stock trading data set. This data set contains the financial information of the selected firms, which is collected from RESSET Financial Research Database (www.resset.cn). We use the Shanghai Composite Index and the Shenzhen Component Index as the market index. It is noted that the stock market index does not refer to the bonus reinvestment, so we only adjust the trading data without considering it. In this way, the trading data can be in accordance with the market index [15].

(2) Internet-based news data set. We use a focused crawler to automatically collect a bundle of news articles related with the selected firms within the study period. Specifically, 4448 news articles are collected from several important financial news portal including Hexun.com, JRJ.com and Finance.Sina.com. Then we exclude stories in the first week after a firm has been newly added to the index to prevent the well-known price increase associated with a firm's inclusion in the Shanghai Composite Index or Shenzhen Component Index [16]. News articles which are released during the twenty minutes before the closure of the market are regarded as the news in the next day [13]. Similarly, if the news articles are released in the non-market days, they are account to the next day's data. For example, the news on weekends is treated as the data of next Monday.

Quantifying the Content of News

Financial news contains lots of information which can affect economic activities. To investigate the impact of financial news on stock market, we first use text mining technique to convert the unstructured news document to structured vector. Each document (news) is treated as a term vector where term weight is valued by the standard TF*IDF definition [17]. With such transformation, we can apply SVR (Support Vector Regression) technique to analyze the relation between the news and stock market. Most traditional machine learning techniques, such as Neural Network, embody Empirical Risk Minimization (ERM) principle which minimizes the error in the training data. However, these traditional approaches can result in
overfitting to the training data. According to Gunn [18], SVR is based on Structure Risk Minimization (SRM) principle, which minimizes an upper bound on the expected risk. It can build a much more accurate and robust regression model to solve overfitting perfectly. That’s the reason why we choose SVR to measure the impact of news articles on stock market. In applying the SVR technology, we consider the news documents vectors as the input of SVR, and the corresponding stocks returns as the output. Meanwhile, we divide the news dataset into training data set (2921 news articles) and testing data set (1527 news articles). With the training data set, we build our regression model. And then we use testing data set to evaluate the SVR performance. Finally, we use the final SVR model to quantify the content of Internet-based news articles and get the news indicator (news), so as to analyze the impact of news stories on stock market.

Econometric Analysis Method

Here, we introduce two ways—event study methodology and cross-sectional regression method to analyze the impact of Internet-based news articles on stock returns respectively. (1) Event study methodology. In this paper, we use the standard event study methodology as described by MacKinlay [19]. We define the date when a piece of news is released in the Internet media as the event day. We then choose the event windows that are the period over which stock return react to the event. We define \( t \) as the event day. We employ a 10-day event window, denoted by \([t-2, t+7]\). \( t-2 \) means two days before the event day. \( t+7 \) means the seventh day after the event day. We set the estimation window at 180 transaction days prior to the event window. The timing sequence is illustrated with a time line in Figure 1.

![Figure 1 Time line for an event study](image)

We adopt the Capital Asset Pricing Model (CAPM) as our market model. The CAPM due to Sharpe [20] and Lintner [21] is an equilibrium theory where the expected return of a given asset is determined by its covariance with the market portfolio. The following CAPM market model was estimated for each news-related firm.

\[
r_{i,t} = r_{f,t} + \beta_i (r_{M,t} - r_{f,t}) + \epsilon_{i,t},
\]

Where \( \epsilon_{i,t} \) is the zero mean disturbance term. \( r_{i,t} \) is the anticipated normal return for the stock of firm \( i \) in period \( t \). \( r_{f,t} \) is non-risk interest rate. \( r_{M,t} \) is the return of portfolio, which we respectively use Shanghai comprehensive index and Shenzhen component index to present. We use the Ordinary Least Square (OLS) method to estimate parameter \( \beta_i \). Then we calculate the abnormal return for the stock of firm \( i \) in period \( t \).

\[
ar_{i,t} = r_{i,t} - \bar{r}_{i,t}.
\]

\( ar_{i,t} \) is the abnormal return for the stock of firm \( i \) in period \( t \). \( r_{i,t} \) is the actual return for the stock of firm \( i \) in period \( t \).

Then we calculate the average abnormal return and the cumulative average abnormal return in equation (3) and (4), which are respectively denoted by \( AAR_i \) and \( CAR_i \).

\[
AAR_i = \frac{1}{n} \sum_{t=1}^{n} ar_{i,t}
\]

\[
CAR_i = \sum_{t=1}^{n} AAR_i
\]

(2) Cross-sectional analysis of abnormal returns. In this section we provide a multivariate analysis of abnormal returns. Specifically, we explore whether the observed abnormal returns are affected by various factors that describe the firm characteristics as well as overall market conditions. The following is the multivariate regression model.

\[
CAR_i = a + b_1 \text{news} + b_2 \ln \text{Size} + b_3 \text{Trmv} + b_4 \text{EP} + b_5 \text{PB} + \epsilon
\]

Where \( CAR_i \) is the cumulative abnormal return of the news-related firm \( i \) from \( t-2 \) to \( t+j \). \( \text{news} \) is the qualified indicator of news articles calculated by SVR, which is used to explore the relation between news and stock market. \( \ln \text{Size} \) is the nature log of the firm scale which is presented by the firm’s total share capital. \( \text{Trmv} \) is the daily turnover rate, which is a very important indicator of liquidity. \( \text{EP} \) is the earnings-price ratio. And \( \text{PB} \) is the price-equity ratio.

EXPERIMENTAL STUDY

Event study of the stock market

In order to study if the news events have an impact on the stock market, we test the simple relationship using the event study method. In Table 1, we discuss the interaction between the news events and the whole stock market that includes the Shanghai and Shenzhen stock market. To well understand the trends of stock price, here is a graphical description about the AAR & CAR for various windows surrounding the event day in Figure 2. In a nutshell, it is observed that stock price decreases as time goes on until the fifth day after the news events. This is quite understandable that the effect of a news stories on stock price is negative and strong during the first several days but to be gradually attenuated with the time passing by. However, there are two peaks in the curve of CAR.

- The first peak occurs on day \( t \), the event day, when the news is released. Here, the AAR is -0.0048 and the CAR reaches -0.0089. They are both very significant at the statistical level of 1%, which indicates a strong and immediate impact on stock price. We can easily understand that on the news event day, all of the investors have acquired the information, so it results in an immediate change of the stock price.
- The second peak occurs on day \( t+5 \). On that day the stock price drops to the lowest level. Meanwhile, we can observe that there is a relatively continuous and particular change from day \( t+2 \) to day \( t+5 \), and the CAR changes from -0.0106 to a minimum of -0.0162. Since it is a long time after the

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news, the investors might have just been brought eyeballs to the other issues so that the influence is almost to the ends. Therefore, the stock price is gradually going back to its normal status. So, it actually reveals that most firms’ stock performance is affected by the news reports from the internet media. In addition, we can easily discover that AAR & CAR are lower than zero, it reflect the news stories has a negative impact on the stock price, no matter how positive and negative the news articles are. This is different from the study of Tetlock [1].

### TABLE I. THE SIMPLE INTERACTION BETWEEN THE NEWS AND STOCK MARKET

<table>
<thead>
<tr>
<th></th>
<th>t-2</th>
<th>t-1</th>
<th>t</th>
<th>t+1</th>
<th>t+2</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAR</td>
<td>-0.0004</td>
<td>-0.0036***</td>
<td>-0.0048***</td>
<td>0.0000</td>
<td>-0.0017***</td>
</tr>
<tr>
<td>CAR</td>
<td>-0.0004</td>
<td>-0.0040***</td>
<td>-0.0089***</td>
<td>-0.0089</td>
<td>-0.0106</td>
</tr>
<tr>
<td>AAR</td>
<td></td>
<td></td>
<td>t+3</td>
<td>t+4</td>
<td>t+5</td>
</tr>
<tr>
<td>CAR</td>
<td></td>
<td></td>
<td></td>
<td>t+6</td>
<td>t+7</td>
</tr>
<tr>
<td>AAR</td>
<td>0.0019***</td>
<td>-0.0022***</td>
<td>-0.0015**</td>
<td>0.0014</td>
<td>-0.0012**</td>
</tr>
<tr>
<td>CAR</td>
<td>-0.0125***</td>
<td>-0.0147***</td>
<td>-0.0162***</td>
<td>-0.0147</td>
<td>-0.0159***</td>
</tr>
</tbody>
</table>

*Notes: The different asterisk (*, **, ****) denotes stationarity on the basis of each test at the 10%, 5%, and 1% statistical level respectively, similarly hereinafter.*

### FIGURE II. TRENDS OF THE STOCK PRICE WITH NEWS EVENTS

### TABLE II. THE SIMPLE INTERACTION BETWEEN THE NEWS AND SHANGHAI STOCK MARKET

<table>
<thead>
<tr>
<th></th>
<th>t-2</th>
<th>t-1</th>
<th>t</th>
<th>t+1</th>
<th>t+2</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAR</td>
<td>0.0007</td>
<td>-0.0034***</td>
<td>-0.0034**</td>
<td>0.0008</td>
<td>-0.0007</td>
</tr>
<tr>
<td>CAR</td>
<td>0.0007</td>
<td>-0.0027</td>
<td>-0.0061**</td>
<td>-0.0069**</td>
<td>-0.0076*</td>
</tr>
<tr>
<td>AAR</td>
<td></td>
<td></td>
<td>t+3</td>
<td>t+4</td>
<td>t+5</td>
</tr>
<tr>
<td>CAR</td>
<td></td>
<td></td>
<td></td>
<td>t+6</td>
<td>t+7</td>
</tr>
<tr>
<td>AAR</td>
<td>0.0045***</td>
<td>-0.0031***</td>
<td>-0.0011</td>
<td>0.0010</td>
<td>-0.0022**</td>
</tr>
<tr>
<td>CAR</td>
<td>-0.0121***</td>
<td>-0.0152***</td>
<td>-0.0162***</td>
<td>-0.0152***</td>
<td>-0.0174***</td>
</tr>
</tbody>
</table>

### FIGURE III. TRENDS OF THE STOCK PRICE WITH NEWS EVENTS ON SHANGHAI STOCK MARKET

It is known that the firms which are listed in Shanghai Stock Exchange are mostly the state-owned big enterprises, while the other firms listed in Shenzhen Stock Exchange are private-owned and small. Due to the difference about the firms in each stock market, we explore the impact of news articles on different stock market respectively in table 2 (figure 3) and table 3 (figure 4).

- Event study of Shanghai stock market.
- Event study of Shenzhen stock market.

When the news stories are reported, the stock has a negative movement on day t quickly. Then it lasts several days because that the t-statistical test of AAR & CAR are of great significance in three days: day t, day t+3, and day t+4. The CAR reaches a maximum of -0.0152 on the fourth day after the news event day.

- Event study of Shenzhen stock market.

We can see a different exploration of the interaction in Shenzhen stock market from table 3 and figure 4 using the
standard event study method. The influential duration is also about five days with a negative impact. On the event day, the AAR is -0.0062 and CAR is -0.115, both having a significance on 1% level. Furthermore, there is another three responses to the news articles after the event which almost as the same as that in Shanghai stock market. But the impact lasts only five days due to the non-significance of AAR & CAR in the following days (day t+6, day t+7) in table 3.

Cross-sectional analysis of Shanghai Stock Market

The results of the cross-sectional analysis in Shanghai stock market are presented in table 4. We examine the heteroskedasticity using the White's test [22]. The robust t-statistics of the regression are displayed in parentheses. The coefficients of the news are significant, particularly from t+1 to t+4, which can indicate that the news articles have a great influence on the stock returns. However, the impact is gradually attenuated as time goes on because of the reduction of t-statistical level. Also, it is obvious that the indicators about firm scale (lnSize) and turnover rate (Trnv) have high level of significance. It reveals that the investors have an enthusiastic response when the news is released. To do the further analysis, we can find the model performs excellence on t+1, for the adjusted R-squared reaches up to 0.441. In addition, the firm scale (lnSize) is less significant from t to t+2, but turnover rate (Trnv) is significant in these days. We can conclude that whatever the firm scale is, news articles always induce strong influence on stock. In the following days, the firm scale (lnSize) becomes more and more significant. It means there is different impact on the firms, whose scales are different.

TABLE III. THE SIMPLE INTERACTION BETWEEN THE NEWS AND SHENZHEN STOCK MARKET

<table>
<thead>
<tr>
<th></th>
<th>t-2</th>
<th>t-1</th>
<th>t</th>
<th>t+1</th>
<th>t+2</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAR</td>
<td>-0.0015</td>
<td>-0.0038</td>
<td>-0.0062***</td>
<td>0.0007</td>
<td>-0.0026***</td>
</tr>
<tr>
<td>CAR</td>
<td>-0.0015</td>
<td>-0.0053</td>
<td>-0.0115***</td>
<td>-0.0108</td>
<td>-0.0134***</td>
</tr>
<tr>
<td>t+3</td>
<td>0.0005</td>
<td>-0.015***</td>
<td>-0.0018**</td>
<td>0.0019</td>
<td>-0.0001</td>
</tr>
<tr>
<td>CAR</td>
<td>-0.0129</td>
<td>-0.0143**</td>
<td>-0.0161***</td>
<td>-0.0143</td>
<td>-0.0145</td>
</tr>
</tbody>
</table>

TABLE IV. THE RESULTS OF MULTIVARIATE REGRESSION MODEL FOR SHANGHAI STOCK MARKET

<table>
<thead>
<tr>
<th></th>
<th>a</th>
<th>b1(news)</th>
<th>b2(lnSize)</th>
<th>b3(Trnv)</th>
<th>b4(EP)</th>
<th>b5(PB)</th>
<th>adj.R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>t</td>
<td>0.065</td>
<td>-0.091*</td>
<td>-0.002</td>
<td>-0.009***</td>
<td>-0.948**</td>
<td>0.0009</td>
<td>0.329</td>
</tr>
<tr>
<td></td>
<td>(-1.038)</td>
<td>(-1.743)</td>
<td>(-0.549)</td>
<td>(5.761)</td>
<td>(-2.536)</td>
<td>(-0.643)</td>
<td></td>
</tr>
<tr>
<td>t+1</td>
<td>-0.098</td>
<td>-0.090***</td>
<td>0.005</td>
<td>-0.007***</td>
<td>-1.388***</td>
<td>-0.0005</td>
<td>0.441</td>
</tr>
<tr>
<td></td>
<td>(-1.038)</td>
<td>(-3.524)</td>
<td>(1.350)</td>
<td>(-4.371)</td>
<td>(-3.340)</td>
<td>(-0.205)</td>
<td></td>
</tr>
<tr>
<td>t+2</td>
<td>-0.047</td>
<td>-0.085**</td>
<td>0.003</td>
<td>-0.009***</td>
<td>-1.579***</td>
<td>-0.0001</td>
<td>0.297</td>
</tr>
<tr>
<td></td>
<td>(-0.390)</td>
<td>(-2.423)</td>
<td>(0.683)</td>
<td>(-4.0002)</td>
<td>(-2.893)</td>
<td>(-0.450)</td>
<td></td>
</tr>
<tr>
<td>t+3</td>
<td>-0.198</td>
<td>-0.109***</td>
<td>0.009*</td>
<td>-0.008***</td>
<td>-1.978***</td>
<td>0.0022</td>
<td>0.282</td>
</tr>
<tr>
<td></td>
<td>(-1.472)</td>
<td>(-2.456)</td>
<td>(1.675)</td>
<td>(-3.223)</td>
<td>(-3.191)</td>
<td>(0.928)</td>
<td></td>
</tr>
<tr>
<td>t+4</td>
<td>-0.293</td>
<td>-0.103**</td>
<td>0.014**</td>
<td>-0.009***</td>
<td>-2.649***</td>
<td>-0.0011</td>
<td>0.363</td>
</tr>
<tr>
<td></td>
<td>(-1.994)</td>
<td>(-2.215)</td>
<td>(2.366)</td>
<td>(-3.32)</td>
<td>(-3.991)</td>
<td>(-0.359)</td>
<td></td>
</tr>
<tr>
<td>t+5</td>
<td>-0.396</td>
<td>-0.093*</td>
<td>0.018***</td>
<td>-0.006**</td>
<td>-2.841***</td>
<td>0.0002</td>
<td>0.336</td>
</tr>
<tr>
<td></td>
<td>(-2.639)</td>
<td>(-1.960)</td>
<td>(2.990)</td>
<td>(-2.424)</td>
<td>(-4.184)</td>
<td>(0.057)</td>
<td></td>
</tr>
<tr>
<td>t+6</td>
<td>-0.520</td>
<td>-0.108**</td>
<td>0.023***</td>
<td>-0.003</td>
<td>-3.047***</td>
<td>0.0025</td>
<td>0.288</td>
</tr>
<tr>
<td></td>
<td>(-3.245)</td>
<td>(-2.125)</td>
<td>(3.485)</td>
<td>(-1.264)</td>
<td>(-4.122)</td>
<td>(0.895)</td>
<td></td>
</tr>
<tr>
<td>t+7</td>
<td>-0.589</td>
<td>-0.090*</td>
<td>0.026***</td>
<td>-0.004</td>
<td>-3.411***</td>
<td>0.0022</td>
<td>0.338</td>
</tr>
<tr>
<td></td>
<td>(-3.688)</td>
<td>(-1.775)</td>
<td>(3.980)</td>
<td>(-1.563)</td>
<td>(-4.588)</td>
<td>(0.796)</td>
<td></td>
</tr>
</tbody>
</table>

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Cross-sectional analysis of Shenzhen Stock Market

Table 5 shows the result of cross-sectional analysis in Shenzhen Stock Market. From the table, we can see the coefficients of the news are significant and negative as well. The conclusion is the same as that of Shanghai Stock Market. Then, we can discover the absolute coefficient of the news is 0.235 on the day t, which is the largest absolute value among all those days. And it is decreasing as time goes by. So, we can draw a conclusion that the strongest impact of news articles on stock happens on the date of t, on which day news articles are released. The influence lasts from t to t+7, which is longer than that of Shanghai stock market.

At the same time, we find the coefficients of turnover rate (Trnv) are also very significant during the event window. However, the significance of firm scale (InSize) is not so obvious. Thus, we can draw the conclusion that no matter what scale the firm may be, there is always strong influence of news articles on stock. The relationship between the impact and firm scale (InSize) is not obvious, even though we add the news indicator. This is similar to the study of Wei Wang [23].

<table>
<thead>
<tr>
<th>TABLE V. THE RESULTS OF MULTIVARIATE REGRESSION MODEL FOR SHENZHEN STOCK MARKET</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>t</td>
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<tr>
<td></td>
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<tr>
<td>t+1</td>
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<tr>
<td></td>
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<tr>
<td>t+2</td>
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<td>t+3</td>
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<td></td>
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<td>t+4</td>
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<td>t+5</td>
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<td></td>
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<td>t+6</td>
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<td></td>
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<tr>
<td>t+7</td>
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</tbody>
</table>

Comparing the results of Shanghai stock market and Shenzhen stock market, we can discover some findings as follows.

First, the news articles have impact on both of the stock markets. Especially, the indicators about news articles (news), turnover rate (Trnv) of the two stock markets are all significant.

Second, the influence of news articles on Shenzhen stock market is stronger than that of Shanghai stock market. From table 4 and table 5, we can note that the maximum absolute coefficient of news in Shenzhen stock market is 0.235, but that is 0.108 in Shanghai stock market. The minimum value of news in Shenzhen stock market is 0.12, while that is 0.049 in Shanghai stock market.

Third, news articles have different impact on the firms, which has different scales. The coefficient of firm scale (InSize) is significant to a certain degree in Shanghai stock market. However, the result of firm scale (InSize) is not noticeable in Shenzhen stock market.

Finally, the duration of the news articles’ influence on stock is different in the two stock markets. The impact strength and duration of Shenzhen stock market are stronger and longer than that of Shanghai stock market.

The impact of different types of news articles on stock market

By using the text mining technique, we automatically divide the news articles into four categories: (1) the capacity of profitability, (2) personnel reshuffle and lawsuit, (3) new product offerings and strategic cooperation, and (4) mergers and financing. Table 6 shows the news variable (news) of cross-sectional regression models which are based on different types of news articles about the whole stock market. We can find the first three categories have significant impact on the stock market. When the news stories are released, there is an immediate negative impact on the stock, especially the news articles about the capacity of profitability. However, the stock market is not sensitive to the news articles about mergers and financing. We find this kind of news articles are not reported very frequently but last long, which is different from the other types of news articles. Thus, we can conclude that news with different contents have different impact on the stock market.

<table>
<thead>
<tr>
<th>TABLE VI. THE RESULTS OF MULTIVARIATE REGRESSION MODEL WITH DIFFERENT TYPES OF NEWS ARTICLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>The 11th International DSI and the 16th APDSI Joint Meeting, Taipei, Taiwan, July 12 – 16, 2011, pp.448-455</td>
</tr>
</tbody>
</table>

453
CONCLUSION

This research is dedicated to investigating the influence of news articles on stock market in China by quantifying the Internet-based news articles using support vector regression technology. Our intention is to assist the government in supervising the securities market and help the individual investor make intelligent decisions. In particular, we explore the impact of different types of news articles on stock market, and compare the stocks’ performance in two markets including Shanghai and Shenzhen stock market. In this study, there are several interesting findings summarized as follows: (1) Internet-based financial news tends to have a negative impact on the movements of Chinese stock market, no matter how positive and negative the news articles are. (2) The firms listed in Shenzhen Stock Exchange react much stronger and the impact lasts a longer period than that in Shanghai Stock Exchange. Note that the characteristics of firms in two markets are different, we conclude that the smaller the firms are, the more information can be noticed. (3) News articles with different contents have different impact on the stock price. When the news stories are released, there is an immediate negative impact on the stock, especially the news articles about the capacity of profitability. This study can be extended in a few interesting ways. First, more online information sources can be considered. For example, we can enrich the information sources for the public by mining messages from Internet-based forum, Blog and twitter. In addition, we do not yet take much numeric time series data into account. A more sophisticated econometric model can be considered for more accurate analysis so as to achieve higher quality.

REFERENCES

THE EFFECT OF THE ONLINE SOCIAL NETWORK STRUCTURE CHARACTERISTICS ON NETWORK INVOLVEMENT AND CONSUMER PURCHASING INTENTION: FOCUS ON KOREAN SOCIAL PROMOTION SITES

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ABSTRACT

The study aims to understand how the characteristics of online social network structure (tie strength, network density, network centrality and homophily, etc.) can impact consumer purchase intention through network involvement. This study focuses on social promotion sites (social commerce sites) like TicketMonster which is the most popular deal-of-the-day website in South Korea etc. These sites have a social aspect. Each promotion is valid only if a certain minimum number of consumers purchase the deal, and the news of these deal-of-the-day websites spreads virally through Facebook updates and Twitter tweets or other social network sites on a daily basis as people encourage family, friends and others within their social networks to sign up for the offer, so that the deal becomes available to all. So we propose and analyze that a consumer’s decision for purchasing in the deal-of-the-day websites is affected by the characteristics of the online social network structure through consumers’ network involvement. The results of this study are: Strong ties with friends can increase their affective involvement to the network. And network density, network centrality and homophily can both increase SNS users’ affective involvement and cognitive involvement to the online social network, both of which can increase their purchase intention to the recommended deals by their friends in SNS.

Keywords: Online social network, Social commerce, Purchase intention, Network involvement

1. INTRODUCTION

Since we use the internet as a commercial instrument, most of the offline retailers have set up online retail stores directly or by third-parties to increase revenues. Nowadays we can see a special phenomenon that lots of e-commerce sites using SNS (social network services) as online shopping tools to post customer ratings, reviews, and user recommendations. They utilize SNS as the effective WOM tools for consumers to share the shopping information and experiences.

SNS (social network service) is a web-based individual – centered service, platform, or site that focuses on building and reflecting of social networks or social relations among people. Facebook, MySpace, Cyworld, Twitter, and so forth are the most popular social network sites. They are virtual communities which allow people to connect and interact with each other on a particular subject or to just “hang out” together online [1], and where everyone is welcome to join through a simple register process, these sites typically allow members to create an online profile containing self-descriptions, react to the profiles of other members, and become “friends” with other members [2][3]. Participants may use the sites to keep in touch with existing friends or to meet new people [2]. By 2011, the world’s largest social network site – Facebook has reached 700 million users and has more than 500 million active users. Social network sites have three common elements. They allow individuals to (1) construct a public or semi-public profile within a bounded system, (2) articulate a list of other users with whom they share a connection, and (3) view and traverse their list of connections and those made by others within the system [4].

Besides the online social network sites, the mobile social network service is also becoming more and more popular for the fast developing of smart phones. “Kakao Talk”, the most popular mobile messenger application in South Korea, was launched in March, 2010. In a year, it has more than 10 million users. Over 100 million messages are sent and received through Kakao Talk daily. It is the mobile social network service which recommends friends to the user by their contact information in their smartphone, or directly added by the users’ ID. This function can lead to easy establishing a real social network through the application.

Wikipedia defined social commerce as a subset of electronic commerce that involves using social media, online media that supports social interaction and user contributions to assist in the online buying and selling of products and services [44]. In brief social commerce is the use of social networks in the context of e-commerce transactions. Nowadays, we call the social promotion sites like Groupon which is the largest deal of the day website in USA and TicketMonster which is the largest deal of the day website in South Korea and other similar sites as social commerce. These sites are the integrated form of SNS, electronic commerce and group buying.
These sites have a social aspect. Each promotion is valid only if a certain minimum number of consumers purchase the deal, and the news of these deal-of-the-day websites spreads virally through Facebook updates and Twitter tweets or other social network sites on a daily basis as people encourage family, friends and others within their social networks to sign up for the offer, so that the deal becomes available to all. Social commerce can (1) make consumers' collaboration easier, (2) make a more rational purchase decision, and (3) make the shopping focused on consumers instead of products by using the SNS.

The purpose of our study is to investigate the SNS structure characteristics and how these characteristics can affect the consumers’ network involvement which may lead to increase purchase intention to the recommended deals by other friends through SNS. We focus on the people who have used the SNS (like Facebook, Twitter, Cyworld, Me2day, or mobile SNS like Kakao Talk etc.) in South Korea.

The article is organized as follows. First, from the existing literature the model and hypotheses are developed. We discuss the influences of four types of network structure characteristics (tie strength, network density, network centrality, and homophily). Then the impact of these characteristics on network involvement, and purchase intention to the recommended deals by the friends in SNS are discussed. Next, we describe the data and empirical analyses used to test the model and hypotheses. Finally, results, conclusions, discussions, limitations and future research directions are discussed.

2. THEORETICAL FRAMEWORK AND RESEARCH HYPOTHESES

In this research, we attempt to develop an in-depth understanding of how online social network structure characteristics influence individuals’ responses to the social commerce sites’ deals recommended by their online social network friends. To do so, we begin with a discussion of the Stimulus-Organism-Response (S-O-R) framework. The S-O-R framework posits that environmental cues act as stimuli that affect an individual’s cognitive and affective reactions, which in turn, affect behavior [5]. Stimulus may include the factors like store environment, product display etc. in the offline store [6] and the web design, posts, etc. in online store [7]. Organism refers to the individual’s cognitive and affective states. And responses include nonverbal responses such as galvanic skin responses, verbal responses like word of mouth communication. And also the behavior responses like acquisition, usage, etc. belong into this realm [6]. Following S-O-R framework, this study operationalizes “stimulus” as the online social network structure characteristics (i.e. tie strength, network centrality, network density, and homophily), “organism” as network involvement (cognitive and affective) and “response” as the purchase intention to the recommended deals by online social network friends. See the Fig.1 for a summary of the research model.

2.1 Tie strength

Tie strength is a “combination of the amount of time, the emotional intensity, the intimacy (mutual confiding) and reciprocal services which characterize the tie” [8]. The strength of tie is different by the interaction frequency, quality and the quantity among network members. For the different degree of the tie strength, it can be divided into strong ties and weak ties [9]. Granovetter (1982) [10] noted that weak ties provided people with access to information and resources beyond those available in their...
own social circles; but strong ties have greater motivation to be of assistance and are typically more easily available. Weak ties distribute information more efficiently than strong ties since strong ties tend to be intra-clique and so less likely to provide new information [8]. Weak ties have some advantages to provide new information, while strong ties more focus on the mobilization, which means that if you need and ask someone for help, they will be willing to help you anytime and always not refuse the request. People in insecure positions are more likely to resort to the development of strong ties for protection and uncertainty reduction [10]. Strong ties constitute a base of trust that can reduce resistance and provide comfort in the face of uncertainty [11]. Weak ties are those who know each other, but don’t meet a lot. So from the weak ties, it is easy to get some new and useful information which are difficult to get from the strong ties, because of they meet each other frequently, and know each other and the information around them a lot. From the antecedent research, we think the strong ties can provide the emotional support and weak ties may give some utilitarian information in online social network. Therefore, we hypothesize that:

H1a. The tie strength (strong ties) will increase the SNS users’ affective involvement to the network.

H1b. The tie strength (weak ties) will increase the SNS users’ cognitive involvement to the network.

2.2 Network density

Tie strength is individual characteristic of the network members, but density can be the whole network’s characteristic, which means connection degree of all the members. The best network density is all the members are connecting with each other in a network. Network density reflects the average strength of relations in a network [12]. High levels of network density is useful for making the norms and values among network members by tacit behavior and expectation, because all the people are knowing each other very well [13]. High levels of information sharing among members of a dense network result in shared beliefs [14] and high levels of consensus among network participants [15].

There are three characteristics of high density network referred by Son [16]. First, high density can lead to much more channels to collect and diffuse the information, so the information and resources flow will be very fast. Second, it is so easy to share the norms, establish reliability and do the mutual imitation, etc. And third, it is very effective for sanction of breaking the promise because the evaluation by others can be delivered very easily and quickly to all the network members. In our study, we posist that the network density can affect the SNS users’ network involvement for the high network density can lead to gain the information easily and establish higher reliability among members in online social network. Therefore, we hypothesize that:

H2a. Network density can increase the SNS users’ affective involvement to the network.

H2b. Network density can increase the SNS users’ cognitive involvement to the network.

2.3 Network centrality

Centrality indicates the degree to individual’s central position in a network. A person who is in a position that permits direct contact with many others should begin to see himself/herself and be seen by those others as a major channel of information, and he/she is likely to develop a sense of being in the mainstream of information flow in the network [17]. A central agent occupies a position of prominence for at least a portion of an agent network [18], influencing information flows and behavioral expectations among other agents [19]. Centrality was used to evaluate an actor’s prominence [20] or power [21]. There are three types of centrality, stating that degree centrality, closeness centrality, and betweenness centrality. Degree centrality defined by the number of ties he or she has with other actors in the network [19]. Closeness centrality defines an actor’s ability to access independently all other members of the network, and betweenness centrality was defined as the extent to which an actor has control over other actors’ access to various regions of the network [17]. Based on these researches, we can find that a person in a central position can gain information easily and deliver information quickly, also will have more power than other network members. From the research of Richmond (1990) [22], we can find out that power is associated with cognitive and affective learning. Therefore, we hypothesize that:

H3a. Network centrality can increase the SNS users’ affective involvement to the network.

H3b. Network centrality can increase the SNS users’ cognitive involvement to the network.

2.4 Homophily

The homophily means group composition in terms of the similarity of members’ characteristics which refer to social identities that are attached externally to individuals (e.g., gender, race, or age) or to internal states concerning values, beliefs, or norms [23]. The similarity of individuals leads to a greater level of interpersonal attraction, trust, and understanding, and consequently, greater levels of social affiliation than that would be expected among dissimilar individuals [24]. From this perspective, we can find that the similarity of individuals can offer some emotional
supports. The principle of homophily is that people who are similar in sociodemographic characteristics are more likely to interact with each other than are people who dissimilar [25]. People associate with similar others because of easeful communication, shared cultural tastes [26] and other features that smooth the coordination of activity and communication [27]. From this perspective, homophily might relate to the cognitive process. In our study we assumed that SNS users have the similar interests with their SNS friends, which can affect their network involvement. Therefore, we hypothesize that:

H4a. The homophily can increase the SNS users’ affective involvement to the network.

H4b. The homophily can increase the SNS users’ cognitive involvement to the network.

2.5 Network involvement and purchase intention to the recommended deals by friends through SNS

Involvement is defined as a person’s perceived relevance of the object based on inherent needs, values and interests [28]. Two aspects of network involvement are investigated: affective involvement and cognitive involvement. Cognitive involvement is associated with “rational, thinking” and is induced by utilitarian or cognitive motives [29]. Affective involvement is associated with “emotional, hedonistic” and is derived from value-expressive or affective motives [29].

Mcmillan (2003) [30] showed that the involvement with the website is positively related to the attitude towards websites which in turn influences consumers’ intention to purchase at the website. Eroglu (2003) [31] demonstrated that consumers’ cognitive states and emotional feeling states have an impact on shopping outcomes. In our study, we focus on the SNS users’ involvement with their online social network, and high affective involvement to the network will lead the positive feeling to their online social network, and high cognitive involvement will improve the efficiency of information processing on their social networking service. Positive feeling states include “happy” and “satisfied” [32] are positively relate to the attitude toward their friends’ activities in the social network. Therefore, we hypothesize that:

H5a. Affective involvement to the network can increase SNS users’ purchase intention to the recommended deals by online social network friends.

H5b. Cognitive involvement to the network can increase SNS users’ purchase intention to the recommended deals by online social network friends.

3. RESEARCH METHOD

3.1 Data collection

Data was collected from online and offline in Korea. 178 surveys were received from college students, and 23 surveys were received by online survey system. In order to get more appropriate data, we just focus on the people who had the SNS using experiences. In a total of 201 respondents, there are 2 people who didn’t use SNS before, so we ignored their respondents. Among the respondents 54.8% were male and 45.2% were female. There are 92.5% respondents are using Cyworld which is the most popular SNS in South Korea, and 34.2% are using Facebook, 67.3% are using Twitter; Mobile SNS is very popular these days in Korea, there are 74.4% people are using Kakao talk which is the most popular mobile messenger in Korea. Among the respondents, there are 42.2 % respondents had social commerce sites using experiences. And there are 183 Korean, 14 Chinese, 1 Spanish, 1 Taiwanese in our respondents.

3.2 Measurement

Numerous prior relevant studies were reviewed to ensure that a comprehensive list of measures was included. The majority of the scale items were adopted from the existing literature but adapted to this study. Tie strength (5 items) measures are obtained and modified from Granovetter (1973) [8] and Petroczi (2007) [33]. Network density (6 items) and network centrality (4 items) measures were adapted from Anita and Fraizer (2001) [34]. Items for measuring the homophily (5 items) were adapted from Mcpherson (2001) [27]. Both affective network involvement (5 items) and cognitive network involvement (5 items) were adapted from Zaichkowsky (1994) [35]. Purchase intention to the recommend deal by friends in SNS (4 items) were obtained from (Li et al., 2002) [36]. The scale items used seven-point semantic differential scales. Items with low loadings on the corresponding construct were eliminated to enhance the reliability of measures.

3.3 Statistical Analysis

The structural equation modeling (SEM) approach was used to validate the research model. This approach was chosen because of its ability to test casual relationships between constructs with multiple measurement items [37]. Lisrel 8.8 will be used in this study to test the study’s hypotheses, and before this we also use SPSS 18.0 to do the exploratory factor analysis and reliability test.

4. RESULT

4.1 Test of reliability and confirmatory factor analysis (CFA)

We first run an exploratory factor analysis on all 34 items.
Table 1
Results of CFA for each constructs

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Indicators</th>
<th>Standardized factor loadings</th>
<th>Standard deviation</th>
<th>t-value</th>
<th>Cronbach α</th>
<th>AVE</th>
<th>CR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tie Strength</td>
<td>x1</td>
<td>0.80</td>
<td>0.36</td>
<td>12.54</td>
<td>0.785</td>
<td>0.649</td>
<td>0.784</td>
</tr>
<tr>
<td></td>
<td>x2</td>
<td>0.81</td>
<td>0.34</td>
<td>12.74</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Network Density</td>
<td>x3</td>
<td>0.85</td>
<td>0.28</td>
<td>13.65</td>
<td>0.793</td>
<td>0.659</td>
<td>0.794</td>
</tr>
<tr>
<td></td>
<td>x4</td>
<td>0.77</td>
<td>0.40</td>
<td>12.11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Network Centrality</td>
<td>x5</td>
<td>0.94</td>
<td>0.12</td>
<td>16.56</td>
<td>0.922</td>
<td>0.859</td>
<td>0.924</td>
</tr>
<tr>
<td></td>
<td>x6</td>
<td>0.91</td>
<td>0.16</td>
<td>15.98</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Homophily</td>
<td>x7</td>
<td>0.83</td>
<td>0.31</td>
<td>13.88</td>
<td>0.888</td>
<td>0.736</td>
<td>0.893</td>
</tr>
<tr>
<td></td>
<td>x8</td>
<td>0.83</td>
<td>0.31</td>
<td>13.89</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>x9</td>
<td>0.91</td>
<td>0.17</td>
<td>16.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Affective Involvement</td>
<td>y1</td>
<td>0.91</td>
<td>0.16</td>
<td>16.53</td>
<td>0.925</td>
<td>0.805</td>
<td>0.925</td>
</tr>
<tr>
<td></td>
<td>y2</td>
<td>0.91</td>
<td>0.17</td>
<td>16.45</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>y3</td>
<td>0.86</td>
<td>0.25</td>
<td>15.06</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognitive Involvement</td>
<td>y4</td>
<td>0.91</td>
<td>0.16</td>
<td>16.37</td>
<td>0.928</td>
<td>0.869</td>
<td>0.930</td>
</tr>
<tr>
<td></td>
<td>y5</td>
<td>0.95</td>
<td>0.10</td>
<td>17.36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purchase Intention</td>
<td>y6</td>
<td>0.94</td>
<td>0.11</td>
<td>15.05</td>
<td>0.930</td>
<td>0.874</td>
<td>0.933</td>
</tr>
<tr>
<td></td>
<td>y7</td>
<td>0.92</td>
<td>0.14</td>
<td>14.72</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chi-Square = 149.41 (P=0.00)</td>
<td>DF = 83</td>
<td>GFI = 0.91</td>
<td>CFI = 0.99</td>
<td>NFI = 0.97</td>
<td>AGFI = 0.86</td>
<td>RMR = 0.041</td>
<td>RMSEA = 0.064</td>
</tr>
</tbody>
</table>

Note: CR – composite reliability, AVE – average variance extracted

by SPSS to assess their dimensionality, factor structure, and measurement properties. Some items are eliminated because of cross loadings and low coefficients. As a rule of thumb, a measurement items loads highly if its loading coefficient is above 0.6 and does non load highly if its loading coefficient is below 0.4 [38]. In our study, we eliminated all the items which are below 0.6. Construct reliability was assessed using Cronbach’s alpha value. Nunnally (1978) [39] recommends that the Cronbach alpha of a scale should be greater than 0.7 for items to be used together as a construct. Therefore, all our constructs are in the acceptable range as shown in Table 1. Then, we run CFA by Lirisel 8.8. The results were shown in Table 1, and demonstrate good measurement fit: the chi-square value is 149.41 (df = 83), CFI, GFI, and NFI have the values of 0.99, 0.91 and 0.97 are higher than 0.9, RMSEA’s value is 0.064 which is less than 0.08. The model fit parameters are in the acceptable range [40].

Table 2
Discriminant validity

<table>
<thead>
<tr>
<th></th>
<th>Tie Strength</th>
<th>Network Density</th>
<th>Network Centrality</th>
<th>Homophily</th>
<th>Affective Involvement</th>
<th>Cognitive Involvement</th>
<th>Purchase Intention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tie Strength</td>
<td>0.81</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Network Density</td>
<td>0.63</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Network Centrality</td>
<td>0.55</td>
<td>0.81</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Homophily</td>
<td>0.60</td>
<td>0.57</td>
<td>0.59</td>
<td>0.86</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Affective Involvement</td>
<td>0.51</td>
<td>0.52</td>
<td>0.51</td>
<td>0.51</td>
<td>0.90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognitive Involvement</td>
<td>0.46</td>
<td>0.59</td>
<td>0.55</td>
<td>0.54</td>
<td>0.73</td>
<td>0.93</td>
<td></td>
</tr>
<tr>
<td>Purchase Intention</td>
<td>0.38</td>
<td>0.29</td>
<td>0.30</td>
<td>0.30</td>
<td>0.41</td>
<td>0.39</td>
<td>0.94</td>
</tr>
</tbody>
</table>

Notes: Bolded diagonal elements are the square root of AVE for each construct off-diagonal elements are the correlations between constructs.
Table 3
Results of hypotheses

<table>
<thead>
<tr>
<th>H</th>
<th>Hypothetical Path</th>
<th>N</th>
<th>Path Coefficient</th>
<th>T-value</th>
<th>Accept/Reject</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1a</td>
<td>Strong Ties→Affective Involvement</td>
<td>γ11</td>
<td>0.17</td>
<td>2.13</td>
<td>Accept</td>
</tr>
<tr>
<td>H1b</td>
<td>Weak Ties →Cognitive Involvement</td>
<td>γ21</td>
<td>-0.01</td>
<td>-0.08</td>
<td>Reject</td>
</tr>
<tr>
<td>H2a</td>
<td>Network Density→Affective Involvement</td>
<td>γ12</td>
<td>0.20</td>
<td>2.45</td>
<td>Accept</td>
</tr>
<tr>
<td>H2b</td>
<td>Network Density→Cognitive Involvement</td>
<td>γ22</td>
<td>0.33</td>
<td>4.26</td>
<td>Accept</td>
</tr>
<tr>
<td>H3a</td>
<td>Network Centrality→Affective Involvement</td>
<td>γ13</td>
<td>0.19</td>
<td>2.51</td>
<td>Accept</td>
</tr>
<tr>
<td>H3b</td>
<td>Network Centrality→Cognitive Involvement</td>
<td>γ23</td>
<td>0.23</td>
<td>3.05</td>
<td>Accept</td>
</tr>
<tr>
<td>H4a</td>
<td>Homophily→Affective Involvement</td>
<td>γ14</td>
<td>0.18</td>
<td>2.36</td>
<td>Accept</td>
</tr>
<tr>
<td>H4b</td>
<td>Homophily→Cognitive Involvement</td>
<td>γ24</td>
<td>0.22</td>
<td>2.98</td>
<td>Accept</td>
</tr>
<tr>
<td>H5a</td>
<td>Affective Involvement→Purchase Intention</td>
<td>β11</td>
<td>0.25</td>
<td>2.68</td>
<td>Accept</td>
</tr>
<tr>
<td>H5b</td>
<td>Cognitive Involvement→Purchase Intention</td>
<td>β12</td>
<td>0.21</td>
<td>2.17</td>
<td>Accept</td>
</tr>
</tbody>
</table>

Note: p<0.05

For the convergent validity, all factors should have the average variance extracted (AVE) higher than 0.50 and composite reliability (CR) should higher than 0.70 [41]. Convergent validity indicates the extent to which the items of scale that are theoretically related to each. As shown in Table 1, shown, all AVE and CR values of the items are acceptable.

Discriminant validity was assessed to ensure whether the construct is different from others. In this measurement, the square root of the AVE for each factor should be higher than the correlations between the factor and other factors [41]. As shown in Table 2, the square roots of AVE which are in bold, it demonstrates adequate discriminant validity of all constructs.

4.2 Test of hypotheses

We used the structural equation modeling (SEM) approach in our data analysis to test the structural and measurement models. Table 3 shows the results of hypotheses testing. Most of the hypotheses were supported except the H1b, weak ties had no significant influence on the cognitive involvement to the online social network. Purchase intention to the recommended deals by other SNS users was explained by the network involvement – affective involvement (β11 = 0.25, p<0.05) and cognitive involvement (β12 = 0.21, p<0.05), providing support to H5a and H5b. Affective involvement was influenced by tie strength (strong ties) (γ11 = 0.17, p<0.05), network density (γ12 = 0.20, p<0.50), network centrality (γ13 = 0.19, p<0.05) and homophily (γ14 = 0.18, p<0.05), providing support to H1a, H2a, H3a and H4a. And Cognitive involvement was influenced by network density (γ22 = 0.33, p<0.05), network centrality (γ23 = 0.23, p<0.05) and homophily (γ24 = 0.22, p<0.05), providing support to H2b, H3b and H4b.

5. CONCLUSION AND DISCUSSION

This study investigates the effect of consumers’ online social network structure characteristics on their network involvement which might affect their purchase intention to the recommended deals by their friends in SNS. We adopt four types of network structure which are tie strength, network density, network centrality and homophily. The results show that all these characteristics have positive effects to the consumers’ affective network involvement and cognitive network involvement except weak ties, and their affective and cognitive involvement, both of which can increase their purchase intention to the recommended deals by their friends in SNS. Let’s rethink about why weak ties don’t have some effects on the online SNS users’ network involvement.

Weak ties are generally infrequently maintain, non-intimate connections, this is focus on the offline, maybe for some reasons that someone couldn’t reach their old friends, so it’s difficult for them to exchange information, so we use this background to assumed that online social network users who are weak ties also can offer some new information like offline networks. But weak ties may be affected positively when the medium expands the reach and basis for initiating and maintaining ties, providing a means through which previously unconnected individuals can now initiate contact [42] [43]. Especially in SNS, it is a two-way communication environment. Even you don’t need to find some information on your own initiative, you can receive all the information that your connected friends in your SNS have done. So in SNS environment, people may think there is not so much weak ties because they are all connect with each other all the time, and can easy reach anyone any time.
From this study, we find out that the integrate SNS with electronic commerce can increase the consumers’ purchase intention, and have positive effects to the online sellers. Also the results show the reason why the deals recommended through SNS can increase the profit. We have proved that it is affected by the consumers’ network structure characteristics which we referred in this study, like strong ties with other SNS members, users’ network density, network centrality, and the homophily with others. We suppose that corporates should be integrated with SNS either online or offline, and pay more attention to the SNS marketing to manage the WOM and customer relationship. Also, marketers can utilize the users’ characteristics to find the information leader in the network for more effective marketing.

6. LIMITATIONS AND FUTURE RESEARCH

This study has several empirical and theoretical limitations, which call for further research. First, when we study the SNS users’ social network characteristics we didn’t use the social network analysis approach which was the standard tool for analyzing one’s social network. Future research should use SNA approach to do more accurate analysis of SNS users’ social network structure. Second, we just focus on the characteristics of the network structure, but not some other factors that can lead to the purchase intention in social commerce sites. Some other factors like individual’s personality, cost, perceived risk, innovativeness, and SNS using experience or social commerce sites’ shopping experience and so forth might be useful in further explaining of the purchase intention in the social commerce sites. Third, in our study we just measure the conative response as purchase intention, some more marketing effects should be studied in the future research. Fourth, in our research we collected the data from SNS users, but didn’t take care of whether they have social commerce sites using experience. In order to get more accurate data, it’s necessary to get more social commerce sites users’ data in the future research. And a larger sample size will be helpful in reflecting a more precise measurement of the research model.

REFERENCES


A STUDY OF FACTORS AFFECTING SOCIAL NETWORK USED IN THAILAND

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Nattapat Boonprakate, King Mongkut's University of Technology Thonburi, Thailand, aimaims@hotmail.com

ABSTRACT
Social Network Service (SNS) is popular in Thailand now [25]. Many people have at least one account with Facebook, Twitter or others. People use social network for many reasons such as finding old friends, advertisement. This means that social network is used for both personal and business purposes. Even many people in Thailand use social network services, some of them still don’t use any social network services provided. It is interesting to study the factors that affect the use of social network in Thailand, since the characteristics of Thai people are difference from other countries. Technology Acceptance Model is used to examine the effect of characteristics of Thai people on actual use of social networks. The characteristics of Thai people are considered based on Maslow’s hierarchical Theory of Motivation in 3 concepts which are belongingness and love needs, esteem needs and self-actualization needs. Some researchers found that encouragement has been an effect on good performance. It supports to be a good support of real usage of social network, so it is worth to consider the effect of encouragement on actual usage of social network services. The questionnaires were sent out to collect data from residence of Bangkok and vicinity. As the result, all three needs have effect on perceived ease of use, perceived usefulness and perceived encouragement. Both perceived ease of use and perceived encouragement have effect on perceived usefulness. Finally, perceived ease of use, perceived usefulness, and perceived encouragement have effect on actual usage.

Keywords: Social network service, Technology Acceptance Model (TAM), Social identity, Altruism, Perceived Encouragement

INTRODUCTION
At present, the number of internet users in Thailand is increasing. In the past, Internet was available only for scholars and researchers, but now it has been widely used. Increasing internet usage creates groups of users, who have common interests and want to exchange information about their interesting topics. Social Network is now used widely to support this internet requirement. ComScore announced that many people have decided to register as a member of some social networks significantly [13]. However, there might be other reasons besides connecting people who have the same interest together. It is interest to study the factors that have effect on using social network services.

The Technology Acceptance Model (TAM) has been used in this study. This model considers relationships among task, human, and actual use in term of perceived ease of use and perceived usefulness. These two variables have effect on user’s usage [14]. Perceived usefulness is a belief that the target information technology or information systems will help the user in performing his or her task. Perceived ease of use is a belief that it would be easy to acquire the knowledge for using the information technology or information systems [2] [39]. Also in TAM, these are some factors affecting the level of perceived ease of use and perceived usefulness. Many studies found that human characteristics and social factors have influence on these two constructs [28] [31] [35] [36]. This paper has focused on human characteristics affecting on social network service used. Three dimensions, which are social identity, altruism and telepresence have been considered. Moreover, in TAM, some external variables can be moderator of perceived construct [15]. Perceived encouragement has been considered as this moderator. To do any activities, people require a level of encouragement which might be happen based on human behavior and background.

The research framework of this study is in Figure 1.

Figure 1: Proposed Research Framework
As stated in Kwon and Wen (2010), a social network is defined as a set of social entities that include people and organizations that are connected by a set off socially meaningful relationships and who interact with each other in sharing the value. It adds more relationship services, which are more complex and in different types, than social network services in the past provide [18] [23] [27]. Social network services now mainly are based on web-based services. It allows people to connect for sharing information, building and exploring the relationships [26]. Maslow’s theory stated 5 human needs. The use of social network services can be fulfilled some of these basic needs. Some example are to maintain contact with friends and family [8] [22] to meet new people [8], to blog and to share content and media [38] or to create virtual groups with others, who have similar interests [28] found that interpersonal relationship has been an important factor for explaining the usage of social network services. These examples are located in the level 3 of Maslow’s needs, stated love and belonging.

**HYPOTHESES**

These are many researchers defined social identity [21] [33] [37]. They can be concluded that social identity means the individual’s position in a certain social group. Researchers found that social identity has had an influence on self-esteem establishment [7] [9] [17]. It means that human have to maintain and improve their self-image [16]. Also, Terry et al., 1997 found that social identity has had a significant impact on attitude. Song and Kim, 2006 stated that social identity has had an effect on usage of technology or systems in virtual community services. To maintain social identity, people have to create and maintain relationships with each other. Communication is needed to manage relationships. Social network as one of collaborative systems has a potential useful tool to maintain social identity. This draws an idea that social identity would have an effect on perceived usefulness [12]. To make social network services to collaborate with group members, perceived ease of use should be affected by social identity, same as perceived encouragement [30]. For these reasons, the following hypotheses are created.

**H1a.** Social identity will have an effect on perceived ease of use of a social network service.

**H1b.** Social identity will have an effect on perceived usefulness of a social network service.

**H1c.** Social identity will have an effect on perceived encouragement of a social network service.

Rachlin, 2002 mentioned that altruism is one of factors explaining human characteristic. Altruism is the willingness of helping others or doing good with or without return expectation [5]. Considering contents in social network, some of them are related to altruism. It leads to the assumptions that altruism relates to perceived ease of use, perceived usefulness and perceived encouragement [6]. In addition, the higher altruism is, the higher level of responsibility is [10]. It reflects the level 4 of Maslow’s hierarchy of needs, stated esteem.

**H2a.** Altruism will have an effect on perceived ease of use of a social network service.

**H2b.** Altruism will have an effect on perceived usefulness of a social network service.

**H2c.** Altruism will have an effect on perceived encouragement of a social network service.

There are many researchers explained about telepresence [20] [24] [32]. They defined telepresence as a sort of feeling that a user is present in a virtual environment. To have telepresence, user interface has a significant influence [29]. Social network services have several functions, which use virtual reality to meet user requirements [29]. Information is more accessible when presented in the virtual environment than when it was presented in physical environment [19] [23]. For these evidences, it could be assume that telepresence has an effect on perceived ease of use, perceived usefulness, and also perceived encouragement. The following hypotheses are developed.

**H3a.** Telepresence will have an effect on perceived ease of use of a social network service.

**H3b.** Telepresence will have an effect on perceived usefulness of a social network service.

**H3c.** Telepresence will have an effect on perceived encouragement of a social network service.

To complete TAM model, the following hypotheses are also developed.

**H4.** Perceived ease of use will have an effect on perceived usefulness of a social network service.

**H6.** Perceived ease of use will have an effect on actual use of a social network service.

**H7.** Perceived usefulness will have an effect on actual use of a social network service.

Perceived encouragement was introduced in Compo’s experiment, stated in Compos et al., 1929. He found that performance can be increased by encouragement, especially verbal encouragement. Many researchers also studied about this relationship and found significant evidence [5] [11]. It is interesting to consider the effect of perceived encouragement on perceived usefulness and actual use, so the hypotheses are developed.

**H5.** Perceived encouragement will have an effect on perceived usefulness of a social network service.

**H8.** Perceived encouragement will have an effect on actual use of a social network service.

**RESEARCH METHODS**

**Data collection**

A questionnaire was developed for collecting the data. The population sample was residents in Bangkok and vicinity, who
used social network services. The convenience sampling technique was used to collect the data. 400 questionnaires were received and only 384 questionnaires are usable.

The sample consisted of 46.61% male and 53.39% female participants ranging in age from fifteen to mid-fifties. The majority were in age of 20-29, 15-19 and 30-39 (35.94%, 26.82% and 20.05% respectively). Moreover, most of the respondents had heavily used social network service measured by hours used per week. 35.68% respondents have use more than 20 hours per week and 14.32% have use 16-20 hours per week. Hence, the sample seems to be a good representative of population for analyzing the factors affecting the actual use of social network services.

Table 1: Sample statistics (Gender)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Gender</th>
<th>Numbers</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>179</td>
<td>46.61</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>205</td>
<td>53.39</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>384</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 2: Sample statistics (Age)

<table>
<thead>
<tr>
<th>Age</th>
<th>Numbers</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 15</td>
<td>33</td>
<td>8.59</td>
</tr>
<tr>
<td>15-19</td>
<td>103</td>
<td>26.82</td>
</tr>
<tr>
<td>20-29</td>
<td>138</td>
<td>35.94</td>
</tr>
<tr>
<td>30-39</td>
<td>77</td>
<td>20.05</td>
</tr>
<tr>
<td>40-49</td>
<td>24</td>
<td>6.25</td>
</tr>
<tr>
<td>&gt; 50</td>
<td>9</td>
<td>2.34</td>
</tr>
<tr>
<td>Total</td>
<td>384</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 3: Sample statistics (Hours used per week)

<table>
<thead>
<tr>
<th>Hours used per week</th>
<th>Numbers</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5</td>
<td>38</td>
<td>9.90</td>
</tr>
<tr>
<td>6-10</td>
<td>55</td>
<td>14.32</td>
</tr>
<tr>
<td>11-15</td>
<td>13</td>
<td>3.39</td>
</tr>
<tr>
<td>16-20</td>
<td>141</td>
<td>36.72</td>
</tr>
<tr>
<td>&gt; 20</td>
<td>137</td>
<td>35.68</td>
</tr>
<tr>
<td>Total</td>
<td>384</td>
<td>100</td>
</tr>
</tbody>
</table>

Questionnaire development

Measurements for perceived ease of use, perceived usefulness, and actual use were adapted to fit the social network services context from Thong et al., 2002. The measurement for social identity was adopted from Song and Sim, 2006. For altruism, the measurement was adopted from Bal-tal and Raviv, 1979. The measurement for telepresence was adapted from Kim and Biocca, 2004. The questions for measuring perceived encouragement were adopted from Campos et al., 1929.

Table 4: Summarize of Model Constructs

<table>
<thead>
<tr>
<th>Construct Name</th>
<th>Number of Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Identity</td>
<td>3</td>
</tr>
<tr>
<td>Altruism</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 5: Reliability Statistics

<table>
<thead>
<tr>
<th>Cronbach's Alpha</th>
<th>Number of Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.86</td>
<td>24</td>
</tr>
</tbody>
</table>

DATA ANALYSIS

All data were coded in SPSS version 17 editor. The series of multiple linear models were developed.

Table 6: The multiple linear regression model with perceived ease of use as dependent variable

<table>
<thead>
<tr>
<th>Factor</th>
<th>Coefficient</th>
<th>Hypothesis supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-5.299</td>
<td>H2a</td>
</tr>
<tr>
<td>Altruism</td>
<td>2.153</td>
<td>H3a</td>
</tr>
<tr>
<td>Telepresence</td>
<td>2.147</td>
<td></td>
</tr>
<tr>
<td>Altruism x Telepresence</td>
<td>0.515</td>
<td></td>
</tr>
</tbody>
</table>

Table 6 shows the result of factors affecting on perceived ease of use at significant level α =0.05 with adjust $R^2 = 0.204$. The result means that both altruism and telepresence have an effect on perceived ease of used. People used social network to show their good willing to other people because it has user interface that is easy to use and response to use requirement. However, social identity has no effect on perceived ease of use.

Table 7: The multiple linear regression model with perceived usefulness as dependent variable

<table>
<thead>
<tr>
<th>Factor</th>
<th>Coefficient</th>
<th>Hypothesis supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-12.789</td>
<td>H1b</td>
</tr>
<tr>
<td>Social Identity</td>
<td>1.027</td>
<td>H2b</td>
</tr>
<tr>
<td>Altruism</td>
<td>5.470</td>
<td>H3b</td>
</tr>
<tr>
<td>Telepresence</td>
<td>1.867</td>
<td></td>
</tr>
<tr>
<td>Telepresence x Altruism</td>
<td>-0.821</td>
<td></td>
</tr>
<tr>
<td>Social Identity x Altruism</td>
<td>-0.630</td>
<td></td>
</tr>
<tr>
<td>Social Identity x Telepresence</td>
<td>0.442</td>
<td></td>
</tr>
</tbody>
</table>
Table 7 shows the result of factors affecting on perceived usefulness at significant level $\alpha = 0.05$ with adjust $R^2 = 0.524$. The result means that all social identity, altruism, and telepresence have an effect on perceive usefulness. It shows that all of them are considered at the same time when people feel usefulness of social networks.

Table 8: The multiple linear regression model with perceived encouragement as dependent variable

<table>
<thead>
<tr>
<th>Factor</th>
<th>Coefficient</th>
<th>Hypothesis supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-3.851</td>
<td></td>
</tr>
<tr>
<td>Altruism</td>
<td>1.713</td>
<td>H2c</td>
</tr>
<tr>
<td>Telepresence</td>
<td>1.668</td>
<td>H3c</td>
</tr>
<tr>
<td>Altruism x Telepresence</td>
<td>-0.395</td>
<td></td>
</tr>
</tbody>
</table>

Table 8 shows the result of factors affecting on perceived encouragement at significant level $\alpha = 0.05$ with adjust $R^2 = 0.289$. The result means that both altruism and telepresence have an effect on perceived encouragement. People use social network to show their care to other people because of its functions [26].

Table 9: The multiple linear regression model with perceived usefulness as dependent variable.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Coefficient</th>
<th>Hypothesis supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-1.184</td>
<td></td>
</tr>
<tr>
<td>Perceived ease of use</td>
<td>1.085</td>
<td>H4</td>
</tr>
<tr>
<td>Perceived encouragement</td>
<td>1.256</td>
<td>H5</td>
</tr>
<tr>
<td>Perceived ease of use x Perceived encouragement</td>
<td>-0.227</td>
<td></td>
</tr>
</tbody>
</table>

Table 9 shows the result of factors affecting on perceived usefulness at significant level $\alpha = 0.05$ with adjust $R^2 = 0.436$. The result means that to get perceived usefulness people has perceived ease of use and perceived encouragement together. People have to know that social network service is easy to use and he/she has others to encourage him/her for using social network.

Table 10: The multiple linear regression model with actual use as dependent variable

<table>
<thead>
<tr>
<th>Factor</th>
<th>Coefficient</th>
<th>Hypothesis supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>2.863</td>
<td></td>
</tr>
<tr>
<td>Perceived ease of use</td>
<td>-0.858</td>
<td>H6</td>
</tr>
<tr>
<td>Perceived usefulness</td>
<td>-0.850</td>
<td>H7</td>
</tr>
<tr>
<td>Perceived encouragement</td>
<td>-0.419</td>
<td>H8</td>
</tr>
<tr>
<td>Perceived ease of use x Perceived encouragement</td>
<td>0.441</td>
<td></td>
</tr>
</tbody>
</table>

Table 10 shows the result of factors affecting on actual use at significant level $\alpha = 0.05$ with adjust $R^2 = 0.308$. The result means that all perceived ease of use, perceived usefulness, and perceived encouragement have effect on actual use as TAM model stated.

Table 11: Summarize of Hypothesis

<table>
<thead>
<tr>
<th>Construct</th>
<th>Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1a. Social identity will have an effect on perceived ease of use of a social network service.</td>
<td>Rejected</td>
</tr>
<tr>
<td>H1b. Social identity will have an effect on perceived usefulness of a social network service.</td>
<td>Supported</td>
</tr>
<tr>
<td>H1c. Social identity will have an effect on perceived encouragement of a social network service.</td>
<td>Rejected</td>
</tr>
<tr>
<td>H2a. Altruism will have an effect on perceived ease of use of a social network service.</td>
<td>Supported</td>
</tr>
<tr>
<td>H2b. Altruism will have an effect on perceived usefulness of a social network service.</td>
<td>Supported</td>
</tr>
<tr>
<td>H2c. Altruism will have an effect on perceived encouragement of a social network service.</td>
<td>Supported</td>
</tr>
<tr>
<td>H3a. Telepresence will have an effect on perceived ease of use of a social network service.</td>
<td>Supported</td>
</tr>
<tr>
<td>H3b. Telepresence will have an effect on perceived usefulness of a social network service.</td>
<td>Supported</td>
</tr>
<tr>
<td>H3c. Telepresence will have an effect on perceived encouragement of a social network service.</td>
<td>Supported</td>
</tr>
<tr>
<td>H4. Perceived ease of use will have an effect on perceived usefulness of a social network service.</td>
<td>Supported</td>
</tr>
<tr>
<td>H5. Perceived encouragement will have an effect on perceived usefulness of a social network service.</td>
<td>Supported</td>
</tr>
<tr>
<td>H6. Perceived ease of use will have an effect on actual use of a social network service.</td>
<td>Supported</td>
</tr>
</tbody>
</table>
H7. Perceived usefulness will have an effect on actual use of a social network service.  
H8. Perceived encouragement will have an effect on actual use of a social network service.

DISCUSSION
Considering the values of adjusted $R^2$ in all multiple linear regression models, there have to be other human characteristics that can affect perceived ease of use, perceived usefulness, and perceived encouragement. People may use social network service as one of presenting channel for presenting their products and services or for broadcasting information. This is the features to do advertising to perspective customers [34].

Moreover, the result shows that at present social network services support the third level of human needs. It is interesting to bring the second level of human needs, security, to study its affect on the use of social network services. This will guide the social network service developers to add more features about personal security requirement in social network services.

CONCLUSION
This empirical study found that all social identity, altruism, and telepresence have effect on social network services usage. This result from this study can be shown in the research framework as follow.

APPENDIX: QUESTION ITEMS USED IN THIS STUDY.

**Perceived usefulness (PU)**
PUI1: Using the SNS enables me acquire more information or meet more people
PUI2: Using the SNS would improve my efficiency in sharing information and connecting with others
PUI3: The SNS is a useful service for communication
PUI4: The SNS is a useful service for interaction of members

**Perceived ease of use (PEoU)**
PPEoU1: Learning to use the SNS is easy for me
PPEoU2: The process of using the SNS is clear and understandable
PPEoU3: I find the SNS easy to use

**Perceived encouragement (PE)**
PPE1: People whom I meet in the SNS tend to give me affirmative evaluation
PPE2: People whom I meet in the SNS tend to be satisfied with me
PPE3: People whom I meet in the SNS give me great encouragement
PPE4: People whom I meet in the SNS tend to be aware of my existence

**Actual use (AU)**
AU1: I tend to use the SNS frequently
AU2: I spend a lot of time on SNS
AU3: I exerted myself to SNS

**Social identity (SI)**
SI1: As a member of the community, my position is very important to me
SI2: As a member of the community, I am the type of person who likes to engage in my community
SI3: Activities in my community are the important part in my life

**Altruism (ALT)**
ALT1: I tend to encourage people who are in a real crisis or need
ALT2: I usually help them the solution when people ask me the solution
ALT3: I give congratulation when people tell me good news

**Telepresence (TELE)**
TELE1: When the SNS ends, I felt like I actually met other people
TELE2: I felt that the SNS creates a new world
TELE3: While engaged with the SNS, I felt I was in a different society
TELE4: While engaged with the SNS, the SNS world was more real or present to me compared to the “real world”

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A FRAMEWORK FOR UNDERSTANDING SOCIAL MEDIA TRENDS IN CHINA

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ABSTRACT

This paper provides an assessment of social media trends in China. An array of social media platforms have emerged for the Chinese market. It is imperative that foreign companies doing business in China understand the trends in order to effectively tap the Chinese market. Traditional social media sites used in the United States, for example, may be banned, making it necessary for companies to utilize sites owned by local Chinese companies. A framework that categorizes social media sites, their primary user groups, and the potential value to companies is presented. Finally, recommendations for companies doing business in China are provided.

Keywords: social media, China, social networks, search engines, internet

INTRODUCTION

China represents a substantial market potential for United States companies, as well as for companies around the world. Not only does China present unique issues in terms of government regulations and involvement in day-to-day operations, but companies also must understand the unique social media platforms in order to reach the millions of potential customers in this market. Companies have been aware of the need to understand cultural differences in China for many years, but the use of social media introduces new complexities when doing business with Chinese consumers.

The array of social media sites available poses a problem. With new sites being added almost daily, the availability of sites is a moving target. In addition, because many of the major sites in the United States are banned in China (e.g., Google, Facebook, Twitter, and YouTube), it is important that companies operating in China understand the implications of government involvement, censorship, and regulation of the Internet and social media sites. Throughout 2010, Google’s interactions and disputes with the Chinese government have highlighted the delicate issue of censorship and strict government control over the Internet. The government’s constant blocking and interference with Western social media and search engine sites has led to increased traffic and revenues for domestic Chinese websites. Local companies have set up social media sites with the same functionality and usability as the Western sites.

Understanding social media in China is a must for companies that do business, or wish to do business, there. China now claims the largest population of Internet users, and all indications point towards continued growth of this population as the Internet becomes more accessible throughout the country. Being able to listen to what people are saying about your company and products is a vital survival strategy. Better understanding of your consumer and engaging with them are the next steps towards social media success.

INTERNET AND SOCIAL MEDIA USAGE

The Chinese are avid users of the Internet and social media. Trends have shown dramatic growth in the number of Internet users and the number of social media sites. The China Internet Network Information Center (CNNIC) was established in 1997 as the government administrative agency responsible for Internet affairs under the Ministry of Information Industry. According to the CNNIC, China’s number of Internet users has grown from approximately 23 million in 2000 to 420 million in June 2010 [5]. This means that China now has more internet users than the United States. The Internet penetration rate in China is estimated at 31.8 percent as of July 2010, which indicates there is still great potential for further Internet user growth.

According to the Ignite Social Media blog (www.ignitesocialmedia.com), China reportedly has 221 million blogs, 117 million bulletin board sites (BBS) and 176 million social network users. Further reported statistics inform that 272 million Chinese are on instant messaging, 222 million use online video, 108 million participate in online shopping, 265 million use online gaming, and 321 million use online music. Furthermore, a reported 92 percent of the total 364 million broadband consumers contribute to social media. Although these numbers are only estimates, the magnitude reveals that social media is indeed very popular in China.

An astounding number of Chinese residents have been reaching the Internet and its content through mobile phones. CNNIC’s 26th Survey Report on Internet Development in China reported that by the end of June 2010, the number of mobile Internet users reached 277 million, accounting for 65.9 percent of the total number of Internet users. Desktop computer access accounted for 73.6 percent and notebook access accounted for 36.8 percent [5]. This trend of increasing mobile phone usage seems poised to continue. Mobile phones are much more affordable than computers and thus are more practical for many Chinese consumers because of their multipurpose functionality. It seems likely that more mobile phones will be sold, and thus, more people will access the Internet through mobile phone devices.

As of June 2010, the top three applications for China’s Internet users were online music (82.5 percent), online news (78.5 percent), and search engines (76.3 percent). Business transaction applications increased from December 2009 to July 2010, of which online payments
increased 36.2 percent during this period. 2010 was the year of large-scale development for business applications. Chinese Internet users are changing their habits from entertainment to business applications.

**LITERATURE REVIEW**

An extensive survey of the academic literature reveals very little research that addresses social media in general. Some recent studies have appeared that are specific to the United States market or focus on U.S. companies. The December 2010 special issue of MIS Quarterly Executive focuses specifically on applications of social media in companies. Of the four articles, two are broad-based studies of U.S. companies [7], [12] and the other two are specific to Starbucks [11] and Dell [10]. A few additional studies were found that evaluate social media sites in the United States [8] or examine the business value of Web 2.0 technologies to companies [1]. All these studies, however, were specific to the United States market. One book [9] was identified that targets an academic audience, but its focus is primarily on the United States market.

No studies were found that address social media issues for China. The Chinese market is probably the most unique in terms of social media sites available and how these sites are being used by consumers as well as the issues associated with government intervention. It is surprising that most of the literature focuses on Western social media trends, primarily the United States.

Several books have been written that focus on providing advice to executives related to incorporating social media into a company’s overall agenda [6] [14] [16]. Li and Bernoff [13], for example, assert that social media will be essential for companies in the future and will change the way business is done. The authors contend that the increasing use of social media is being driven by consumers and that companies must have a better understanding of these consumer motivations and how to tap into the wealth of information being discussed on these sites. The focus, however, is on the United States consumer and written from the viewpoint of U.S. companies.

Several consulting reports address the issues of how companies are using Web 2.0 technologies [2] [3] [4] and how companies are finding value from the use of social media. Although companies were studied worldwide, the focus was on trends in the United States.

The literature points to the need for an evaluation of social media trends and studies of consumer adoption of social media platforms and applications that address key markets such as China. The research on this topic is in its infancy and has not progressed beyond the initial bounds of inception.

This paper lays the foundation for a better understanding of these issues for the Chinese market. China has emerged as the world’s second largest economy, and has the largest population in the world. There is a need to extend the literature to address the unique social media issues and implications for business opportunities and consumer behavior in China, the world’s largest consumer market.

**SOCIAL NETWORKS**

According to iResearch (www.iResearch.com.cn), social networking is a popular activity for Chinese Internet users, especially among students and white-collar users who comprise the majority of Internet users in China. Five main social networking sites exist in China: Renren, Kaixin001, Qzone.qq, Pengyou, and 51.

**Renren**

Renren was founded in 2005 as Xiaonei by Tsinghua University graduates Wang Xing, Wang Huiwen, and Lai Bingjiang. In October 2006, the site was acquired by Chinese internet consortium Oak Pacific Interactive (OPI) and, in August 2009, it officially changed its name to Renren. Xiaonei translates to “on-campus network” because when the site was created, it was for university students only (exactly how Facebook started; one needed a “.edu” e-mail address to join initially). The site is absolutely identical to Facebook and has essentially the same user interface, layout, tools and functions. Just like Facebook, Renren users have an editable profile which features a “wall” where others can leave comments. Users also have the ability to upload photos, videos, and more. Again, similar to Facebook, the site is open to third-party developers. This means an abundance of games and applications are available on the site and online games are among the site’s most popular features.

Renren translates to “everyone network,” which symbolizes how the site opened its registration to everyone, and not solely to students. According to Renren, the “everyone network” is the largest, most influential social networking website available. The site has more than 120 million active users.

According to Alexa Internet (www.alexa.com), a highly recognized web information database, Renren is ranked 15 in China and 94 worldwide in traffic volume. The site has reported revenue of $30 million, an estimated 15 percent market share, and a 60 percent growth in the number of users. In 2008, the site launched a WAP version, making Renren accessible through mobile phones. This was a critical move; as mentioned earlier, 65.9 percent of China’s Internet users access the Internet through mobile phones. This trend will continue, as mobile phones are much more affordable and prevalent than personal computers. Renren’s main source of revenue comes from its advertising sales.

Renren’s target demographic is students. Recently, the site has shifted a lot of attention to trying to keep students using the site after they graduate. In fall 2009, the site launched a big advertising campaign urging Chinese to use the site to reconnect with old friends and classmates.
Kaixin001

Launched in 2008, Kaixin001 translates to “Happy Net.” Oak Pacific Interactive launched this copy so that Renren and Kaixin001 users could have one registration for both sites. In 2011, it ranked as the 27th most popular website in China and 150th overall according to Alexa Internet. The site experienced rapid initial growth, amassing 7.5 million users in its first five months. The most recent reports put the number of registered users around 75 million. While Renren’s primary target is students, Kaixin001’s target audience is white-collar workers who use the site at work. Most notably, the site has highly active members, who average 15 page views and 15 minutes per visit. The site features online file sharing, offering each user 1 GB of online storage space. The site’s popularity is centered around its abundance of addictive online games, the top two being “Friends for Sale” (where users price and sell friends) and “Happy Farm” (users grow vegetables and steal vegetables from friends).

Qzone.qq

The Chinese Internet giant Tencent Holdings created Q Zone in 2005 to be the social networking component of its qq.com online community. More than 200 million registered users blog, upload photos, and listen to music on the site. While QQ ranks as the 10th highest traffic site in the world and the second highest in China, according to Alexa.com, Q Zone accounts for 23 percent of QQ’s overall site traffic. About 150 million users update their accounts at least once a month, which makes Q Zone one of the most active websites in the industry.

Pengyou

Tencent released a new social networking site in July 2010 called Pengyou, which translates to “friends” in English. The site targets white-collar workers and students. It appears that the site’s difference from Q Zone is that it is intended more for one’s real-life friends, whereas Q Zone is more for one’s qq instant messaging friends. The new site appears to be an attempt by Tencent to further compete against Renren and Kaixin001 by attracting an older audience. Alexa ranks this site as 25th in China and 195 worldwide.

51

Entrepreneur Mr. Pang Sheng Dong founded 51 in August 2005 in Shanghai, China. The site is jointly invested by Sequoia Capital, SIG Asia Investments, Giant Interactive, Intel Capital, Redpoint Venures, and other enterprises and funds. According to the site’s own information, it is the largest social network service provider in China. As of June 2009, the site had approximately 160 million registered users. The site started in lower-tier, more rural cities, and has had slow growth since. According to Alexa, 51 is visited more frequently by users who are in the age range 18 to 24, have children, and have no college education. Alexa ranks the site as the 735th highest traffic site in China. The site is an open platform, but does not have nearly as many games or applications as Renren.

These five sites appear to be the most popular social networking sites in China, but there are countless others. It appears that Renren will continue to grow and establish itself as the premier social networking site, much like Facebook. Tencent’s new site, “Pengyou,” may emerge as a major competitor.

SEARCH ENGINES AND WEB PORTALS

Baidu (NASDAQ: BIDU)

Baidu was incorporated in 2000 and since has grown to become the leading Chinese language search engine. Baidu ranks seventh in the world and 1st in China in Alexa’s internet rankings as of April 2011. Baidu proactively censors its content to stay in accordance with the Chinese government’s strict regulations. Considering China already represents the largest number of Internet users with expected continued growth, Baidu is an extremely important site to be aware of when discussing any type of online content in China. Baidu generates revenue primarily through focusing on online marketing services. Its Pay for Placement (P4P) platform allows customers to pay to have better search results and links for a keyword/company name. Baidu closely resembles Google, but is the dominant search engine in China because of its censorship and natural Chinese language services.

Hao123

Hao123 is China’s largest web directory and navigational site. Launched in 1999 it was acquired by Baidu Inc. in 2004. Hao123’s homepage consists of more than 200 outbound links that lead to other popular Chinese websites. Users with a Baidu login name can create a customized homepage with “My Hao123” (similar to Google’s iGoogle) that provides 10 customized URLs and a unique background. The site has an Alexa traffic rank of 12th in China and 113th in the world as of April 2011.

Soso

Soso launched in 1998 and is a Chinese search engine owned by Tencent Holdings Limited. As of April 2011, Alexa Internet ranked the site tenth in China and 43rd in the world in terms of traffic volume. Alexa statistics show that the majority of the site’s users are female, in the age range 25 to 34, college-educated, and they browse from work or school. The site’s image and interface closely mimic Google.

Sohu Inc. (NASDAQ: SOHU)

Sohu is a search engine company headquartered in Beijing. The site provides news, information, video content, entertainment and communication services. In November 2005, Sohu was selected to be the Official Internet Content Service Sponsor of the Beijing 2008 Olympic Games. Sohu was provided exclusive services to construct, operate
and host the official Beijing Olympics website. News.sohu.com is the most popular subdomain on the site, attracting approximately 23 percent of the site traffic, according to Alexa. As of April 2011, Alexa ranked Sohu the eighth most visited site in China and the 42nd most visited in the world.

Sogou

Sohu Inc. also owns the search engine site Sogou, which was launched August 4, 2004. Sogou translates to “search dog” in Chinese. The site serves as Sohu Inc.’s search engine, as the domain sohu.com has become more of a web portal, making the sogou.com domain the specialized search engine. Alexa ranks Sogou as the 23rd most visited site in China and 106th in the world.

Sina (NASDAQ: SINA)

Sina was launched in 1999 and now is the largest Chinese language infotainment portal (most similar to Yahoo.com). Alexa ranks the site’s traffic as third highest in China and 13th overall in the world. The sports, blog, and news components of the site are the most frequently visited. According to Alexa, the site is more frequently visited by users who are in the age range 25 to 34, are college educated, and browse this site from work and or school.

163

NetEase is a Chinese Internet company that operates the domain 163.com, a popular web portal. The site has been live since 1997 and features news, blogs, e-mail, and more. One of the more popular features of the site is its internally developed, massively multiplayer online games, many of which charge users for playing time. The site is ranked sixth for Internet traffic in China by Alexa, and 28th globally. Alexa also reports that 163 is visited more frequently by users who are in the age range 25 to 34, are college educated, and browse the site from work.

BLOG, FORUM AND USER REVIEW SITES

Tianya.cn

Launched in 1999, Tianya.cn is one of the most popular online forums, also known as BBS sites in China. These sites are extremely popular as they are topic-centric, and people use them to discuss and review virtually everything, including consumer goods and companies. Alexa currently ranks Tianya.cn 20th in China in terms of traffic and 112th in the world. Due to the site’s widespread popularity, Chinese politicians have used the site to campaign. According to Webdetail (www.webdetail.org), the site garners approximately 12,400,990 daily page views and earns $31,250 USD in daily ad income as of October 2010.

Blogbus

Blogbus was launched in 2002 and is one of the most popular BBS sites. As of April 2011, Alexa ranked Blogbus 143rd in China and stated that it is visited more frequently by users who are in the 25 to 34 age range, have no children, are college educated and browse the site from work. The site hosts countless blogs and has become a popular way for companies to interact with consumers.

Douban

Launched in 2005, Douban is a web 2.0 Chinese website that features user reviews and recommendations for books, music, and movies. A new popular feature is an online radio application that streams music tailored to individual preferences (much like U.S.-based Pandora.com). According to Alexa, Douban currently ranks 22nd in China in terms of traffic and is visited more frequently by females who are in the of 25 to 34 age group, have no children, are college educated and browse the site from work.

Sina Weibo (Microblog)

Sina Weibo is the equivalent of Twitter in China. The domain is t.sina.com.cn. In 2009, China’s main information portal, Sina, launched the microblog, Weibo. This launch came on the heels of the government shutdown of Fanfou, which was China’s most popular microblog at the time. At this same time, Twitter was blocked by the Chinese government due to the ethnic riots in Xinjiang. The popularity of Weibo is now similar to that of Twitter in the rest of the world. [15].

VIDEO SHARING AND HOSTING SITES

Youku Inc. (NYSE: YOKU)

Youku is a video-hosting service that was founded in 2006 by Victor Koo. The company has recently shifted its focus from user-generated content to focus on professionally produced videos licensed from content partners. According to Alexa, the site ranks 9th in China and 49th overall in terms of traffic.

Tudou

Tudou is another video-hosting/sharing website, founded in 2005. According to Alexa, the site ranks 13th in China and 54th overall in terms of traffic. Unlike YouTube, users watch many television shows and movies, as well as user-generated videos. The site represents a great deal of Chinese Internet traffic, especially among the 18-to-34-year-old group.

E-COMMERCE SITES

Taobao

Taobao is an online destination for shopping, socializing, and information sharing. The site is owned by the Alibaba Group and was founded in 2003. Similar to eBay, its focus is on facilitating business-to-consumer and consumer-to-consumer retail through providing a platform to open online retail stores. New or used items can be sold in either fixed price or auction format (like eBay). The overwhelming majority of products sold on Taobao are brand new items sold at fixed price.
As of April 2011, Alexa ranked the site fourth in China in traffic volume and 14th in the world. Alexa also reports that users spend approximately 20 minutes per visit to the site and most users are female between the ages of 25 and 34, college educated, and browse from work.

Other popular e-commerce sites ranked in the top four in China include Paipai, 360buy, and Dangdang.

**ONLINE GAMING AND VIRTUAL GOODS**

**Happy Farm**

Online games are one of the more popular online activities for Chinese. An estimated 15 million urban, white-collar internet users spend more than five hours a day on Happy Farm, according to data from the game’s creator, Five Minutes.

**Tencent**

Chinese Internet giant Tencent, the owner of the instant messaging service QQ and social networking site Q Zone, reported 2008 revenues exceeding $1 billion of which $719 million was generated by sales of virtual goods to Internet users. This market of virtual goods seems to be increasing, and many companies like Tencent and other social networking sites are competing for ways to collect revenue.

**B2C VERSUS B2B**

There is a tendency to think that only business-to-consumer (B2C) companies are utilizing social media. However, many business-to-business (B2B) companies are finding it just as effective. B2C companies are customer facing and use social media to engage and to better understand their customers. B2B companies are more focused on relationships with business partners. Their use of social media is focused on building relationships with these entities. Both types of business models can be successful using social media tools if their use is based on the objectives set out by the company.

B2C companies more likely will find Renren or other social networking companies to be of value for the China market. B2B companies may not find Renren, for example, to be as effective. Similarly, Facebook is not used as readily by B2B companies in the United States. B2B companies may find Youku more effective as a tool to provide training videos or educational materials for suppliers. The use of social media sites in China will vary by company type and business objectives but the basic goals of social media for a B2B company are not too different from a B2C company.

**DISCUSSION OF SOCIAL MEDIA TRENDS**

Figure 1 provides a summary of the current major social media sites in China organized by category. These are identified today as the most popular in each category. These sites are the primary ones companies need to be aware of in order to assess how to best meet the needs of their particular operations in the Chinese market. Social media will continue to increase in influence and use in China. Companies that get on board today will find opportunities and unique ways to understand the needs of their customers in China and to involve them in ways that will impact the bottom line.

For companies thinking about engaging in social media in China, the most practical benefit is that user-generated content is essentially a vast collection of consumer insight. In China, the Bulletin Board sites are particularly popular and provide Chinese users with the option of anonymously uploading pictures, video and more. BBS sites are integrated into the five aforementioned social networking sites - Renren, Kaixin001, Q Zone, Pengyou, and 51. Chinese social media users like to talk about their experiences with products. These opinions, both good and bad, can provide valuable insights and a wealth of information for companies.

Blogs, online games, and videos seem to be the best channels to reach the widest audience in China. Incorporating social media into these channels will be effective in reaching Chinese customers. The content of any material however is extremely important and will factor heavily on the popularity and success of a marketing campaign. As mobile phones are increasingly used for Internet access in China, companies will need to develop mobile social media applications.

<table>
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<tr>
<th>Figure 1: Summary of Search and Social Media Sites in China</th>
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<td><strong>Search Engines</strong></td>
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Social media in China is constantly changing and evolving, and it will become more prevalent in business and consumer activity. According to eMarketer
CONCLUSIONS AND FUTURE RESEARCH

Today, it is imperative that companies doing business in China understand China’s social media landscape. Each company must evaluate the options to determine what portfolio of social media sites work best to meet the objectives of their particular business. B2C companies that are primarily customer facing will utilize social media for a different purpose than those companies that are primarily B2B. In all cases, the plan that works in the United States context, or other country context, is not the plan that will work in China. Companies must be aware of this fact and not assume that they can enter the Chinese market utilizing the social media sites already established in the United States. Resources, expertise and efforts specific to the China market will be necessary for success.

The research presented here sets the stage for more extensive studies to address an array of issues related to the use of social media in companies. Evaluating the benefits of social media applications and assessing the value afforded companies is difficult but necessary in order to justify the resources and evaluate where to target future plans. The contribution of this work is its focus on global trends related to social media, extending the discussion beyond the United States market. Future research is needed to build on this direction as well as an assessment of company and country opportunities and challenges for implementing social media plans.

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The insights below provide companies with a starting point from which to launch their social media initiatives in China.

1. Do not assume that social media initiatives that work in other markets are directly transferable to the Chinese market.
2. Social media is an excellent way to engage Chinese consumers, especially youths and young professionals.
3. Web content for Chinese consumers is best presented in the Chinese language.
4. The Chinese government is a concern and should be monitored because of uncertainty related to censorship of content, potential regulations, and bans on sites.
5. Online games are highly popular and sponsoring or incorporating your brand or product into a game is a great way to gain company exposure and /or brand familiarity.
6. Research reveals that the Chinese consumer trusts companies that have blogs more so than those companies that do not have a blog.
7. Access to the consumer on mobile devices is crucial because more than 60 percent of China’s Internet users access from mobile devices.
8. Chinese consumers provide valuable user-generated content that, in turn, can provide beneficial insights to companies.
9. Popular Internet sites for Chinese users are changing from focusing primarily on entertainment to business applications.
10. Social media will continue to grow and flourish in China.
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* Alexa updates its rankings daily. Those reported in this paper are from April 2011.
THE IMPACTS OF PERCEIVED ORGANIZATIONAL SUPPORT, JOB SATISFACTION, AND ORGANIZATIONAL COMMITMENT ON JOB PERFORMANCE IN HOTEL INDUSTRY

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ABSTRACT
The hotel industry is an international industry, and the market is extremely competitive. Frontline employees are an important human resource for the hotel industry. The objective of this study is to examine the relationships between perceived organizational support, job satisfaction, organizational commitment, and job performance in the hotel industry context. This paper proposes a simple and practical model that helps the decision makers and hotel managers to highlight the most influential factors in developing their hotel’s employee performance. The findings suggest that perceived organizational support has positively significant effects on job satisfaction and organizational commitments while job performance did not reach the significant level.

Keywords: Perceived Organizational Support, Job Satisfaction, Organizational Commitment, Job Performance.

INTRODUCTION
In hotel industry, frontline employees play a crucial role because of people oriented businesses. They can only establish and maintain a long-term relationship with profitable customers is a paramount importance to business success [11]. However, comparing with other industries, hotel industry has no routine holiday and needs to work 24 hours a day, 7 days a week. It is believed that it’s the nature of the work, inadequate pay with service money oriented, long working hours, over workloads, low job security, limited training and development opportunities contribute to an unsatisfied job then turn to a high turnover. Consequently, many studies have found that high turnover is related to job satisfaction [9] and these issues impact on low job performance and low commitments [34]. This problem seems to be on-going and a critical issue for managers in hotel operations worldwide [25]. Therefore, the management of frontline hotel managers has been struggling with these questions, which are, how their employees feel at work and what employees need. Afterwards, it is to understand the hotel employees’ satisfaction with their job and commitment to their organization.

A careful review of the literature indicates that the organizations obtain favorable outcomes from favored treatment of employees. Employees who are treated well are more likely to be committed and involved to their organization [6; 12]. Perceived organizational support is associated with this exchange in that employees will reciprocate favorable treatment when they trust that the organization will reward them. In other words, perceived organizational support is an employees’ formation of global beliefs pertaining to how much the organization cares about their well-being and values their contributions [12]. This concept is based on the social exchange theory [7] and the norm of reciprocity [18]. Social exchange theory explains why employees feel obligated to reciprocate actions directed toward them by the organization. A number of the literature regarding employee-organization relationships has focused on perceived organizational support and positive relationship with job satisfaction and performance [14].

Despite the previous research has found out that the organizational support positively influence job attitudes and job performance [13]. The antecedents and consequences of the job attitude have been a great interest to the behavioral scientists over the last decades [26]. Different studies have shown either positive, negative, or no relationships between job attitudes and job performance [29; 44]. Specifically, several researchers have already discussed the outcomes of organizational support such as the organizational commitments [44], job satisfactions [43], and the performances [36]. To bridge the gap in the employee’s job performance literature, the main purpose of this study attempts to examine the relation of perceived organizational support on frontline employee’s job satisfaction, organizational commitment and job performance in hotel industry. The remainder of the paper is organized as follows. We examine the literature review, and the hypothesized relationships are presented. We next present a comprehensive framework. We then use structural equation modeling (SEM) statistical technique to test the model. After that, the empirical analyses and research findings are reported. In the final section, we discuss managerial implications and recommend the directions for future research.

LITERATURE REVIEWS AND HYPOTHESES DEVELOPMENT

Perceived Organizational Support (POS)
The theoretical foundation of perceived organizational support is an organizational support theory [6; 13], which itself builds on social exchange and attribution processes [7]. Perceived organizational support is the employees’ perception or judgment of how much the organization values their contribution and cares about them [13]. Employees see their employment as a reciprocal exchange relationship that reflects relative dependence and extends beyond a formal contract [12]. Employees need to determine whether, and to what extent, an organization will recognize and reward their effort, support their socio-emotional needs, and help them on request. This perspective is important in organizational
research because employees and organizations are involved in a reciprocal relationship [14]. It is not sufficient only examine one side of this relationship but also consider the support which the organization gives to its employees [8].

Organizational support theory also addresses the psychological processes underlying the consequences of perceived organizational support. Firstly, on the basis of the reciprocity norm, perceived organizational support should produce a felt obligation to care about the organization’s welfare and make employees work harder to help their organization reach its goals. Secondly, the caring, approval, and respect denoted by perceived organizational support should fulfill socio-emotional needs, leading employees to incorporate organizational membership and role status into their social identity. Finally, the perceived organizational support should strengthen employees’ beliefs that the organization recognizes and exchanges social where effort and loyalty are traded for tangible and social rewards which also increases the performance (i.e., performance-reward expectancies). These processes should have favorable outcomes both for employees (e.g., increased job satisfaction and heightened positive mood) and for the organization (e.g., increased affective commitment and performance, reduced turnover) [38].

Job Satisfaction

Job satisfaction is one of the most widely studying and measuring constructs in the organizational behavior and management literature. Job satisfaction has been defined simply as a worker’s positive or negative attitudes toward ones job [19]. Robbins and Judge [40] also defined job satisfaction as ones positive feeling about his or her job, but also further stated that the assessment was based on an evaluation of the job characteristics. Each individual of values, attitudes, and expectations differ; thus, motivational factors can be quite different. The most used research definition of job satisfaction is by Locke [23], who defined it as “a pleasurable or positive emotional state resulting from the appraisal of one’s job or job experiences” (p. 1304). Implicit in Locke’s definition includes evaluative or expectancy components and the importance of both affect, or feeling, and cognition, or thinking. Similarily, job satisfaction is an employee effective response resulting from an evaluation of the work situation. George and Jones [15] further explained that some workers have high intrinsic values and thus desire work to be satisfying regardless of factors such as pay and benefits. Others with high extrinsic values desire high compensation. Benefits represent satisfying many stages of needs for the employees.

Most approaches to the job satisfactions are based on the theories of motivation, among the premise of the Herzberg et al. (1959) theory, known as the Two-Factor Theory of Motivation. Intrinsic factors such as employees' opportunity for personal achievement, recognition from supervisors, the work itself, and the growth are related to job satisfaction. Conversely, extrinsic factors such as company policy, administration, supervision, and working conditions are associated with job dissatisfaction. According to Herzberg (1966), the factors associated with work that are considered to be the motivators include: achievement; recognition; tasks (the work itself); responsibility; advancement; and personal growth. The factors associated with work that are considered to be hygienic include: policies and administration; supervision/managerial relationships; salaries; working conditions; status; security; and coworker relationships.

Research suggests that employees that benefit from the organization’s support will increasingly feel a sense of praise, support, or approval from their organization [6]. In other words, employees must gain this sense of support prior to their reciprocation of supportive human resource practices. Specifically, research has indicated that individuals who perceive that their organization supports them are more likely to be satisfied with their job [2]. Riggle, Edmondson and Hansen [39] conducted a meta-analysis of 167 studies, examining the effects between perceived organizational support and job satisfaction. They concluded that employees, who perceive the organization to be high in the level of support provided, will be significantly less likely to leave the organization. Specifically, perceived organizational support accounted for nearly 38% of the variance of job satisfaction. Findings from the study indicate that perceived organizational support has a strong and positive effect on job satisfaction, and a strong but negative effect on intention to leave [24]. Research thus made the following hypothesis:

H1: Perceived organizational support has positively significant effect on job satisfaction in hotel industry.

Organizational Commitment

The definitions of organizational commitment include an identification with the organization, shared goals and values between the organization and the individual, continuing membership in the organization, and attachment to social relationships in the organization [29]. Maynard et al. [26] pointed out that basically organizational commitment is a structural phenomenon of a transaction between an individual and an organization, and its non-transferable investment result shall increase as time goes on; employees are reluctant to leave the organization because of the salary, status, position, and friendship among colleagues. Organizational commitment is typically conceptualized as being comprised of three parts: a mental state that reflects the necessity (affective commitment), perceived cost associated with leaving the organization; the desire (continuance commitment), and/or the obligation (normative commitment) to remain in the organization [3; 28]. Somers [42] findings suggest that the relative levels of commitment for each employee affect how the more general psychological state of commitment is experienced. For example, when affective commitment and normative commitment are high, the potentially negative effects of continuance commitment are attenuated possibly because employees do not feel stuck in their organizations, but rather invested in them.

There are two main explanations about the link between perceived organizational support and organizational
commitment in the literature. The first is in terms of reciprocity and social exchange to help the organization reach its objectives, created through perceived organizational support. According to this view, employees who believe that their organization values them and cares for their well-being are more likely to feel a sense of obligation toward the organization and, therefore, they reciprocate a favorable treatment with increased loyalty and commitment. The second explanation is in terms of socio-emotional needs. This is the idea that perceived organizational support can help to fulfill important socio-emotional needs of individuals, such as needs for approval, esteem and affiliation, and that such need fulfillment, in turn, enhances employees' affective attachment to and identification with the organization [12; 30]. Thus, higher perceived organizational support should be associated with greater commitment to the organization. Based on the above discussion, research proposes the following hypotheses:

**H2: Perceived organizational support has positively significant effect on job commitment in hotel industry.**

**Job Performance**

Job performance refers to the overall evaluation of how well an individual fits the organization’s expectations [2]. Organizations have been seeking to optimize the job performance of their employees to achieve high levels of productivity, efficiency and effectiveness [1]. Therefore, job performance must be clearly defined and fully understood by the employees who are expected to perform well at work. From a more conceptual perspective, job performance can be generally separated into two parts: (1) task performance and (2) contextual performance [33]. Task performance refers to the role prescribed functions specific to each job title. It encompasses the activities that help support an organization’s technical core or the organization’s system of transforming inputs into outputs. In other words, task performance involves all behaviors that are directly relevant to main job functions and, in short, is the proficiency of activities that formally are recognized as part of employee’s job [32]. In contrast to task performance, which utilizes knowledge about facts and principles is related to an organization’s technical core, contextual performance utilizes knowledge of facts, principles, and procedures, all of which relate to situations that call for helping and cooperating with others. It consists of organizational behaviors that, implicitly or explicitly, are important for organizational effectiveness [32]. This type of performance is not often written in a job description but is nonetheless considered to be an important component of job performance.

According to social exchange accounts that emphasize the norm of reciprocity, the obligation to repay organizational support with performance is considered to be a motive that drives work performance [13]. Armeli et al. [5] found out that there is a positive relationship between perceived organizational support and work performance in study of police patrol officers of an eastern U.S. state police department. Moreover, supervisors’ perceptions that the organization valued their contribution and cared about their wellbeing were found positively related to subordinates’ perceptions of support by the supervisor, which in turn in-role performance, and extra-role performance [41]. The finding from 167 studies in the meta-analysis indicate that perceived organizational support has a moderate, positive effect on both task and contextual performance [39]. Research thus made the following hypothesis:

**H3: Perceived organizational support has positively significant effect on job performance in hotel industry.**

The study of the relationship between job satisfaction and job performance is one of the most venerable research traditions in industrial-organizational psychology. The positive relationship between job satisfaction and job performance has been found in numerous studies [17; 39; 44]. In addition, a more comprehensive review of 301 studies, Judge et al. [22] found that when the correlations are appropriately corrected (for sampling and measurement errors), the average correlation between job satisfaction and job performance is a higher 0.3. Moreover, the relationship between job satisfaction and performance was found to be even higher for complex (e.g., professional) jobs than for less complex jobs. Thus, contrary to earlier reviews, it does appear that job satisfaction is, in fact, predictive of performance, and the relationship is even stronger for professional jobs. Thus, research proposes the following hypothesis:

**H4: Job satisfaction has positively significant effect on job performance in hotel industry.**

The dominant framework in the literature, Meyer and Allen’s [27] three component model, provides a strong basis for delineating the proposed effects of commitment on job performance. Research has shown that such commitment is facilitated by the positive work experiences provided by the organization [31]. In the study of Spanish blue collar workers, employed by a bus company and a water supply company, affective commitment to the organization exerted a positive influence on job performance [4]. Jaramillo, Mulki and Marshall [21] analyzed a meta-analysis that includes studies that are conducted over the past 25 years across 14 countries. The relationship between organizational commitment and job performance was 0.21 for the overall sample, with a 95% confidence interval of 0.20 to 0.23. Hence, a positive relationship exists between organizational commitment and job performance at alpha = 0.05. Findings confirm that organizational commitment positively related to job performance. Research thus made the following hypothesis:

**H5: Job commitment has positively significant effect on job performance in hotel industry.**

Figure 1 show the proposed model based on the above literature review.
METHODOLOGY

Sample
The sample population was chosen from a list maintained by the Taiwan Culture and Tourism Association. A total of 132 hotel’s email addresses and phone numbers were collected. The structured questionnaires were prepared in bilingual, English and Chinese was employed through sending email to general managers, marketing managers and human resource managers with the explanation of frontline employee to fill up starting from the middle of June 2009 to the end of August 2009. A pilot study was conducted to ensure all the questions were understandable and to establish content validity of the questionnaire. A total of 321 questionnaires were collected in the study, 285 questionnaires were usable for the data analysis and whereas 36 were ineffective. The effective rate was eighty-nine percent.

Measurements
All the construct measurements involved in this study were adapted from the previous literature. All questions of constructs were measured using a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). There are seven items to measure perceived organizational support base on the work of Eisenberger et al. [13], and Aselage and Eisenberger [6]. The twenty items “Minnesota Satisfaction Questionnaire” (MSQ) [16] was used to measure job satisfaction construct. The MSQ measures intrinsic satisfaction, extrinsic satisfaction and general satisfaction. For the organizational commitment construct, the study used fifteen items adapted from revised version of Allen and Meyer’s [3] “Three Component Organizational Commitment Questionnaires” (OCQ), including affective, continuance and normative commitments. Job performance was measured in terms of the degree to which respondents felt that they performed their work well including quality, quantity, and creativity aspects. There were eleven items to measure job performance. The questionnaire items were based on Deadrick and Gardner [10] study, with some modification according to the objectives of this study.

RESULTS AND DISCUSSIONS

The demographics analysis of the sample shows that it consisted of 84 (29.5%) males and 201 (70.5%) females. Respondents ranged in age from 20 to 29 years (57.2%), 30 to 39 years (35.8%), 40 to 49 years (6.7%) and over 50 years (0.3%) respectively. Almost half of the employees were college or university education level. Moreover, less than 5 years working experiences in hotel were 74.4% of all the respondents. Construct reliability was assessed by using the Cronbach’s alpha coefficient for each construct and all of them are above the suggested threshold of 0.7, ranged from 0.861 (normative commitment) to 0.972 (perceived organizational support), suggesting that the construct could be used with confidence. Table 1 presents the summary of correlations and descriptive statistics for each of the variables. Structural Equation Model (SEM) was employed to test the overall model fit and the hypothesized relationships of all the variables in the entire model with the use of AMOS 7.0.

Structural Equation Model (SEM)
Figure 2 illustrates the structural equation model with parameter estimates. The fit indices adopted in this study were the comparative fit index (CFI), the normed fit index (NFI), the Tucker Lewis index (TLI), the goodness of fit index (GFI), the adjusted goodness of fit index (AGFI), and the root mean square error of approximation (RMSEA). All the goodness-of-fit indices in this study are based on the criteria recommended by Hair et al., [20]. Chi-square value of 461.5 with 126 degrees of freedom is statistically significant at the 0.000 significance level. However the CMIN/df = 3.663 is acceptable. GFI=0.856, AGFI=0.805, and RMSEA= 0.09 almost the recommended level, so the model is moderately fit for the hypothesized model.
Test of Hypotheses

The results in Table 2 show that all relationships included in the hypothesized direction. The relationship between perceived organizational support and job satisfaction was positively significant (γ = 0.700, p < 0.001). The results indicate that if employee who perceived organizational support, they are more satisfied with their job. The result was consistent with previous literatures [14; 39]. In an organizational context, organizations treat employees well via opportunities for reward, kind of treatment; employees will increasingly feel a sense of praise, support, or approval from their organization then have higher job satisfaction and may reciprocate through effort exerted towards performing well on the job or serving the organization [4; 6]. Thus, hypothesis H1 was supported. Moreover, the relationship between perceived organizational support and job commitment (affective, continuance and normative) was also positively significant (γ = 0.743, p < 0.001, γ = 0.415, p < 0.001, γ = 0.551, p < 0.001).

Path analysis

<table>
<thead>
<tr>
<th>Path analysis</th>
<th>Coefficient</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived Organizational Support → Job Satisfaction</td>
<td>0.700</td>
<td>10.94***</td>
</tr>
<tr>
<td>Perceived Organizational Support → Affective Commitment</td>
<td>0.743</td>
<td>14.28***</td>
</tr>
<tr>
<td>Perceived Organizational Support → Continuance Commitment</td>
<td>0.415</td>
<td>6.19***</td>
</tr>
<tr>
<td>Perceived Organizational Support → Normative Commitment</td>
<td>0.551</td>
<td>8.10***</td>
</tr>
<tr>
<td>Perceived Organizational Support → Job Performance</td>
<td>-0.197</td>
<td>-1.72</td>
</tr>
<tr>
<td>Affective Commitment → Job Performance</td>
<td>0.067</td>
<td>0.83</td>
</tr>
<tr>
<td>Continuance Commitment → Job Performance</td>
<td>0.613</td>
<td>7.89***</td>
</tr>
<tr>
<td>Normative Commitment → Job Performance</td>
<td>0.238</td>
<td>3.56***</td>
</tr>
<tr>
<td>Job Satisfaction → Job Performance</td>
<td>0.482</td>
<td>5.38***</td>
</tr>
</tbody>
</table>

Note: P-value < 0.05, *: P-value < 0.01, **: P-value < 0.001, ***

Table 2. SEM results of hypotheses testing
The study confirms that if employees who believe that their organization supports them and cares for their well-being are more likely to feel a sense of obligation toward the organization and therefore, to reciprocate the favorable treatment with increased loyalty and commitment [12; 30]. Therefore, hypothesis H2 was supported. However, the results show that the relationship between perceived organizational support and job performance did not reach the significant level ($\gamma = -0.197$, $p >0.05$); thus, hypothesis H3 was not supported. The result was not consistent with the prior research. The following reasons could explain such phenomena. In Taiwan hotel industry, it is very rare to write Standard Operation Procedure (SOP) for employees. Most job descriptions are going with the oral. The job title is not clearly defined and written job description is not in details. Therefore, task performance is really weak than contextual performance. It means that how organizational support to the employee, they are confused what to do which in turn low job performance.

As for the relationship between job satisfaction and job performance, the results reveal that job satisfaction had a positive effect on job performance ($\beta = 0.482$, $p <0.001$), which suggests that who have high job satisfaction tend to perform well on their job. The result was also consistent with previous studies [17; 39; 44]. When employees perceive the supportive and accommodating, role clarity and freedom of expression, they will be more satisfied in their jobs and will exert more effort, which leads to higher job performance. In contrast, when employees perceive the organizational environment negatively, they will be less satisfied and exert less effort, resulting in decreased job performance [33]. Thus, hypothesis H4 was supported. The results show that continuance and normative commitments were positively significant effect on job performance ($\beta = 0.613$, $p <0.001$; $\beta = 0.238$, $p <0.001$) whereas affective commitment did not reach the significance level ($\beta = 0.067$, $p > 0.05$). Therefore, hypothesis H5 was partially supported.

Research Implications

In real life, due to the vagueness of human feeling and recognition, it is difficult to exactly evaluate the employee’s performance and their needs. This paper proposes a simple and practical model that helps decision makers and hotel managers to highlight the most influential factors in developing their hotel’s employee performance. The paper may contribute for the management teams to avoid the pay-for-performance program, it may push employees to the point of doing whatever it takes to get the promised monetary reward and in the process, stifle their talents and creativity. Financial motivation and immediacy of reward are particularly important in short-term employment periods, in which people serve, collect their dues, and move on, whereas employers pay only for these short-term services [37]. Furthermore, an organization that puts too much emphasis on pay in attempting to influence behaviors may reduce employees’ intrinsic drives. The hotel management teams should show recognition for frontline employees’ accomplishments and adapt work schedules to meet individual needs whenever possible. For example, care about their opinions, give some necessary help when they have problems, consider their goals and values and so forth. Along with social exchange theory, organization actions favoring to employees should contribute more to perceived organizational support if employees view them as voluntary rather than as the result of external constraints such as government regulations, union pressures, or competitive wages paid by alternative employers [13]. This paper suggests the hotel managers to provide opportunities for professional development, enriches jobs and fulfills the needs related to respect, caring, and approval. In addition, they should create more favorable job conditions such as training opportunities to aid employees in their desires for personal growth and achievement. The paper also suggests writing down the clear Standard Operation Procedure (SOP) to make clear understanding for the employee. Moreover, managers should spend reasonable time with their frontline employees through socialization and training. These efforts could help to minimize the emotional exhaustion on job satisfaction, organizational commitment, and improve the performance.

Research Limitations and Future Directions

The research findings contributes the theoretical and practical implication, however, this study has suffered from few limitations. The results are not generalizable since we examined only frontline employees in the hotel industry. It might have different result from other positions. Moreover, the results could be affected by self-selection bias, and the data are cross-sectional. Therefore, it might to examine the long-term trend of these hypothesized relationships in future studies. Under the restrictions of the study time, funding, and personal knowledge, it was still unable to cover everything. Therefore, some suggestions for future researchers are provided. Firstly, beside the factors discussed in this study, there are other factors which may influence the employee’s attitude, organization commitments to job performance. The researcher can incorporate different factors such as psychological well-being to discuss in the future research as an example of Panaccio and Vandenberghe [35] and culture [44]. Secondly, perceived organizational support is a good predictor of job performance, but employees’ responsiveness to the reciprocity norm provides a basis for understanding how the favorableness and perceived intentionality of treatment received from the organization influence job performance and why employees differ in their reciprocation of favorable treatment. Future researchers can add the factor of organizational spontaneity, and in-role performance to enhance the validity of the study. Thirdly, the data should be collected in a longitudinal trend because social exchange interpretations that stress reciprocation’s role in employee-employer relationships need to built up long term. Finally, future researcher can examine whether different demographics and characteristics can lead to different outcomes. The further study should use qualitative method to get a much deeper inside understanding and to explore the causal relationship among variables.
REFERENCES


The Turnover Warning Model of the Life Insurance Agents

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Hsin-Mei Cheng, Takming University of Science and Technology, Taiwan, f895d046@hotmail.com

ABSTRACT

At present, the global economic development is being at service industry leadership stage, and the key of leading the development of service industry is the human resources; especially in the life insurance industry which relying on human to create the performance is more apparent. Staff turnover may increase recruitment costs and the training time. Furthermore, the life insurance policy service interruption resulted in the policy holders outflow. So, how to decreasing the loss of life insurance field staff which has become an important issue. There are many research past discussed about the behavior of separation, but they are only limited to find the factors of separation and no discussion about the turnover warning. So this research hopes construct the turnover warning model through personality traits, job satisfaction, organizational commitment, job performance, establishing emotional and turnover intention which in order to achieve the effect of turnover warning. In addition, when those talented staff has turnover intention, the model can be used as retention function. The objects of the study are field staff for the life insurance industry in Taiwan, the questionnaire survey method was used, and the research analysis methods were include descriptive statistics, reliability analysis, validity analysis, correlation analysis and structural equation modeling.

Keywords: Life Insurance Agents, Turnover Intention, job satisfaction, Job Performance.

INTRODUCTION

Service industry covers finance and insurance, wholesale and retail, eating and drinking, accommodation, logistics, etc. Among so many numerous sectors, finance and insurance is a manpower-intensive sector. The finance and insurance industry has its unique value between customer relations and customer knowledge. And association of the unique value lies with staff working on the first line [1]. Besides, business personnel are the front line for creating organization’s value. This still more proves the importance of business personnel in the finance and insurance service industry.

A recruiting method adopted by insurance firms is mass recruitment. They utilize field personnel to create handsome sales [2]. For example, currently talent is being lost in the insurance industry. In addition to the aforementioned additional recruitment cost and time in training, this may impact clients’ willingness to continue to pay premium [12]. In the past, there have been many discussions over turnover behavior. Relevant study indicates that the most effective indicator for turnover behavior is turnover intention [4]. Past turnover intention research discussed a number of basic variables of an individual, such as his/her age, education, job seniority, etc. Moreover, personality, job satisfaction, organizational commitment, job performance, and so on, were also often discussed. However, these discussions mostly were aimed to identify factors relevant to turnover intention and lacked a general discussion. Besides, they rarely constructed an alert model for turnover intention. As a result, this study attempts to:

(1) Discuss factors which affect insurance field personnel’s turnover intention;
(2) Construct a model for insurance field personnel’s turnover intention; and
(3) Achieve an alert through the model.

LITERATURE REVIEW

Personality

Allport[11] believed that personality is a dynamic organization of an individual’s psychological and physiological system, which shows his/her unique thoughts and behavior in response to an outside environment. [20] argued that personality may be used to predict an individual’s expressed behavior. [16] proposed internal locus of control (ILC) and external locus of control (ELC), which were developed based on sociological learning theory. ILC: an individual can control effects brought about by the environment and rewards are received as a result of the individual’s efforts. ELC: such personality easily affected by outside environment. Such personality is caused by fate and opportunity and cannot be controlled by oneself. [11] found that with insurance firm salespeople as subjects, personality related to job satisfaction.
**Job Satisfaction**

[8] published Job Satisfaction by first proposing that job satisfaction is staff's satisfaction with their job environment and work psychologically and physiologically. This is an employee's subjective recognition in response to job situation. [7] indicated that job satisfaction is how staff like their work. When work satisfies expectations, staff will have job satisfaction. According to [9] research, job satisfaction will affect job efforts and job performance.

**Organizational Commitment**

Becker (1960) believed that organizational commitment is a continuation of a behavior and that it is also a stake. Once one does not stay at the organization, all vanishes complexly. Previous efforts no longer exist [21]. [14] held that an individual’s identification with a particular organization and the strength of his launch include value commitment, retention commitment, and effort commitment. [4] research found that job satisfaction positively relates to organizational commitment.

**Job Performance**

[15] proposed that job performance consists of three dimensions: quantity of performance, quality of performance, and effort for work. [3] believed that job performance is the degree to which an employee achieves his/her goal and that this reflects how the employee implements his/her missions.

**Turnover Intention**

[14] held that turnover intention is expressed by a total of 4 factors: personal factor (relocation or other career plan), job factor (lack of challenge), organization factor (job environment, job satisfaction or welfare), and external factor (acquisition of a new job). [17] argued that turnover intention describes an individual’s possibility to change jobs during a period of time. With life insurance firms in Taiwan as research subjects, [5] found that the lower the internal satisfaction and the external satisfaction a life insurance employee gets at his job, the higher his turnover intention will be.

**METHODOLOGY**

This research adopted a questionnaire survey, and with life insurance field personnel as research subjects, discussed relevance of personal traits, job satisfaction, organizational commitment, job performance with turnover intention. Based on this, a turnover intention model was constructed in an aim to serve as a turnover alert (see Figure 1). This research consists of 5 hypotheses:

H1: Personality is relevant to job satisfaction.

H2: Personality is relevant to organizational commitment.

H3: Personality is significant to organizational commitment.

H4: Personality, job satisfaction, organizational commitment, and job performance have a significant effect on turnover intention.

H5: Personality, job satisfaction, and organizational commitment have a significant effect on job performance.

This research’s Personality scale was developed based on Rotter’s (1966) scale, revised by Zi-hui Wu (1975), and corrected by referring to [11] scale. The Job Satisfaction scale adopted a scale compiled by Jing-ji Wu & Su-hua Liao short form based on Weiss, Davis, England and Lofgurist’s (1967) “Minnesota Satisfaction Questionnaire”, and then it was corrected by referring to [22] scale. The Organizational Commitment scale was based on the organizational commitment scale constructed by Porter et al. (1979) and corrected by referring to [18] scale. The Turnover Intention scale was based on Karatepe and Kilic’s (2007) scale, translated by [10], and corrected by referring to [6] questions. The Job Performance scale was developed by referring to life insurance salespeople’s average premium revenue per month (FYP), average commission revenue per month of the past year (FYP), average insurance contracts sold per month, and annual income of the past year (various allowances, renewal commissions, year-end bonus…). After analysis, questions with poor reliability and validity were deleted, and the results are provided in Table 1 below:
### Table 1: Analysis of questions on reliability and validity

<table>
<thead>
<tr>
<th>Variable</th>
<th>Dimensions</th>
<th>Items</th>
<th>Factor loading</th>
<th>Cronbach's α</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>I'm busy for the degree, I am ...</td>
<td>0.381</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I'm busy for the degree, I am ...</td>
<td>0.381</td>
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<tr>
<td></td>
<td></td>
<td>For my work give me an opportunity to show alone, I am ...</td>
<td>0.493</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>For my work I often do different things make the opportunity, I feel ...</td>
<td>0.682</td>
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<tr>
<td></td>
<td></td>
<td>will work as colleagues or friends to me, &quot;admiration&quot; for this, I am ...</td>
<td>0.482</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>For me at work opportunities for people to do things, I am ...</td>
<td>0.723</td>
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<td>For me to tell people at work should be the opportunity to do what I am ...</td>
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<td>I can work for their ability to do something the opportunity, I am ...</td>
<td>0.637</td>
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<tr>
<td></td>
<td></td>
<td>I am at work can free to use their own judgments ...</td>
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<tr>
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<td></td>
<td>I am at work to try to do things their own way to the opportunity to feel ...</td>
<td>0.575</td>
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<td>Under way for the boss treat, I am ...</td>
<td>0.702</td>
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<td>The ability to make decisions for the boss, I am ...</td>
<td>0.710</td>
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<td></td>
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<td>My method of implementing the policies of the organization are ...</td>
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<td></td>
<td></td>
<td>I did work on, I can get my pay every month are ...</td>
<td>0.537</td>
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<tr>
<td></td>
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<td>I currently work for the promotion opportunities given to me was ...</td>
<td>0.656</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>My work environment (heating, lighting, ventilation, etc.) Generally speaking,</td>
<td>0.610</td>
<td>0.820</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The units with each other to get along, so I am ...</td>
<td>0.625</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>After good work by praise, so I am ...</td>
<td>0.696</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I currently have a high service life insurance company loyalty.</td>
<td>0.542</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I often tell friends that I serve the life insurance companies is quite an ideal place to work.</td>
<td>0.627</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I am very concerned about the current service life insurance company's future development direction.</td>
<td>0.614</td>
<td>0.927</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I am happy working in the current service life insurance company.</td>
<td>0.570</td>
<td></td>
</tr>
</tbody>
</table>
Table 1 Analysis of questions on reliability and validity (continuous)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Dimensions</th>
<th>Items</th>
<th>Factor loading</th>
<th>Cronbach's α</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Life insurance companies currently serve the work of my achievement and career development, the significance is very important.</td>
<td>0.659</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I am willing to make extra efforts to help companies develop and succeed.</td>
<td>0.727</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I think I have the responsibility to serve the life insurance companies currently doing the best.</td>
<td>0.633</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I feel that life insurance companies currently working in the service, to create their own value in the workplace.</td>
<td>0.532</td>
<td>0.927</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I will do my best to overcome the difficulties of the life insurance field work.</td>
<td>0.811</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Value and Effort Commitment</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I am willing to take my life experience to the New Field colleagues.</td>
<td>0.800</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I will take the initiative to collect information on the life insurance field work or work skills.</td>
<td>0.682</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I often regarded as the interests of the company's own interests.</td>
<td>0.694</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Even worse working conditions, I am still willing to stay in current services, life insurance companies.</td>
<td>0.807</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Even have a better chance, I would not consider leaving the service life insurance companies now.</td>
<td>0.826</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I very much hope that the service life insurance companies currently have to work until retirement.</td>
<td>0.742</td>
<td>0.846</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The current condition of the environment and system, I am happy to stay in current services, life insurance companies.</td>
<td>0.688</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Retention Commitment</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I might find a new job next year.</td>
<td>0.940</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I often want to change jobs.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I might leave in a few months.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I want to leave the insurance industry to other industries.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I went to work for this company after he had actually looked for other work.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Turnover Intention</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Last year, the average monthly first year premium (FYP)</td>
<td>0.865</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Last year, the average monthly first year commission (FYC)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Last year, the average monthly number of insured (including all products)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Annual income in one year (including the grant, renewal commission, bonus ...)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Job performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Personality</td>
<td>0.734</td>
<td></td>
</tr>
</tbody>
</table>
DATA ANALYSIS

This research collected a total of 117 filled questionnaires, including 72 females and 44 males (22.2%). Most are college degree holders (53%) and married (54.7%), job seniority 1~5 years (29.1%), sales personnel (52.1%).

In verifying the Structural Equation Model (SEM), it was found that the default personality is irrelevant to job satisfaction and organizational commitment. And personality, job satisfaction, and organizational commitment will not impact job performance. Besides, job satisfaction and job performance will not affect turnover intention. After variables which will not affect turnover intention were deleted, it was found, through a STM verification, that job satisfaction has a positive effect on organization commitment, that personality is significant to turnover intention, and that organizational commitment is significant to turnover intention. Relevant results are listed in Tables 2 and 3.

### Table 2 Hypothesis testing result (for significant result only)

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1 personality is relevant to job satisfaction.</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>H4 personality, job satisfaction, organizational commitment, and job performance have a significant effect on turnover intention.</td>
<td>0.006</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Personality traits tend to have a significant impact on turnover</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Organizational commitment have a significant impact on turnover intention</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

### Table 3 Goodness of fit index result

<table>
<thead>
<tr>
<th>Goodness of fit index</th>
<th>Criteria</th>
<th>Data</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>χ²</td>
<td>p-value&gt;0.05</td>
<td>393.691(p&gt;0.05)</td>
<td>Yes</td>
</tr>
<tr>
<td>RMSEA</td>
<td>&lt;0.1</td>
<td>0.070</td>
<td>Yes</td>
</tr>
<tr>
<td>NFI</td>
<td>&gt;0.9</td>
<td>0.705</td>
<td>No</td>
</tr>
<tr>
<td>CFI</td>
<td>&gt;0.9</td>
<td>0.861</td>
<td>No</td>
</tr>
<tr>
<td>AIC</td>
<td>as smaller value as better</td>
<td>541.691</td>
<td>No</td>
</tr>
<tr>
<td>PNFI</td>
<td>&gt;0.5</td>
<td>0.587</td>
<td>Yes</td>
</tr>
</tbody>
</table>

### Table 4 Hypothesis Results

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1: personality is relevant to job satisfaction.</td>
<td>Not established</td>
</tr>
<tr>
<td>H2 personality is relevant to organizational commitment.</td>
<td>Not established</td>
</tr>
<tr>
<td>H3 personality is significant to organizational commitment.</td>
<td>Established</td>
</tr>
<tr>
<td>H4 personality, job satisfaction, organizational commitment, and job performance have a significant effect on turnover intention.</td>
<td>Part of the establishment¹</td>
</tr>
<tr>
<td>H5 personality, job satisfaction, and organizational commitment have a significant effect on job performance.</td>
<td>Not established</td>
</tr>
</tbody>
</table>

Note: 1. Personality and organizational commitment have a significant effect on turnover intention, while other variables do not.

CONCLUSION AND DISCUSSIONS

Conclusion

This study aims to discuss correlation of personality, job satisfaction, organizational commitment, and job performance with turnover intention and to construct a turnover intention model. Results of research hypotheses are given in Table 4.
The results find that the higher the job satisfaction in life insurance field personnel, the higher the organizational commitment, and that the higher the ILC, the lower the turnover intention. Besides, when life insurance field personnel identify with organizational commitment, turnover intention is lower relatively. Turnover intention was scored through a turnover intention model using personality and job satisfaction. When a turnover intention score is 3 or higher, an alert is required for the subject. At this time, the superintendent may decide whether to retain the employee.

Discussions
Results from this research show that the higher the life insurance field personnel are satisfied with their jobs, the higher the organizational commitment. This proves researchers’ theory mentioned earlier. The results differ slightly with the original assumptions. The reason may be the life insurance industry’s particularity. The results also find that the higher the ILC, the lower the turnover intention. It was found that most field personnel in the life insurance industry tend to have an ILC. ILC is believed to rely on themselves, rather than on fortune, to tackle everything and difficulty that happen to them. Besides, job performance has no effect on job satisfaction, personality, organizational commitment, or turnover intention. This may be because in the life insurance industry, field personnel do not really pay attention to job performance. Satisfaction at work and commitment from the organization might be more important for life insurance field personnel. Finally, the quantity of questionnaires was not big enough so that the model was not stable.

REFERENCES

THE DIFFERENT PERSONALITY EMPLOYEES AND THEIR FEEDBACK SEEKING BEHAVIOR: DO LEADERSHIP MODERATES?

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Abstract

Feedback seeking is a kind of impression management strategy. When they have good performance, aggressive good feedback seeking can draw supervisors’ attention on their success. When they have bad performance, the proactive bad feedback seeking behavior can manipulate supervisors’ judgments. Our study finding is that Taiwanese employees are shy to do good feedback seeking than bad feedback seeking behavior. Extraversion subordinates tend to do more good and bad feedback seeking behavior than introversion subordinates. Under the consideration leadership, extraversion subordinates exhibit more bad feedback seeking behaviors to influence supervisors’ impressions.

Keywords: Feedback seeking behavior, Impression management, Extraversion, Management style, Chinese Culture

Introduction

Employees receive feedback from many sources (e.g. subordinates, coworkers, or clients) in their working environments. One of the most important feedback sources is supervisors’ feedback (Ashford, 1993) [1]. Because supervisors evaluate the performance appraisal and have the right to give praise, job promotion and penalty. Thus, subordinates value supervisors’ feedback and feedback is not only given by supervisors, but also can be manipulated by subordinates’ doing some proactive behaviors. This kind of proactive behavior is defined as feedback seeking behavior (Ashford and Cummings, 1983) [3]. The proactive feedback seeking behavior have three advantages for subordinates, first, subordinate can obtain more working information to accomplish the goal. Since the supervisor’s feedback reveal his working expectation and direct subordinates some guidelines to follow. These benefits will motive subordinate to seek supervisors’ feedback aggressively.

Second, the motive for subordinates to seek feedback aggressively is that supervisors’ acknowledgement of the level of working performance. Before formal performance appraisal, ask supervisors’ opinion in advance can help subordinates to confirm the level of working performance. At present supervisor’s perception is good or bad and what should they do to fulfill the job and avoid failing jobs. The proactive feedback seeking behavior can help subordinates to acquire job praise and escape from inflicting the punishment.

Third, aggressive feedback seeking behavior also can influence supervisors’ performance judgments (Ashford et al, 2003; Eastman, 1994) [2] [6]. Employees do good feedback seeking behavior to acquire the supervisors’ attention on their good performance and enhance the supervisors’ perception of the quality of their work (Schlenker, 1980; Tedeschi and Norman, 1985) [16] [19]. On the contrary, when employees’ performances are not good, they may use proactive bad feedback seeking behavior to influence supervisors’ evaluation. Subordinates may give some apologies or excuses and try to minimize the supervisors’ potential negative evaluation or emotional feelings (Larson, 1989) [10]. Because culture plays an important role to influence employees’ organization behavior, different culture background employees may exhibit distinct level of feedback seeking behavior. When employees performed well, not everyone is willing to call supervisors’ attention to their achievement. In contrast, when employees performed poorly, they may more aggressive try to correct supervisors’ impressions. Some culture characteristics affect person’s psychological mechanism and behavior. Past research put less emphasis on it and this is our first research purpose to examine the culture difference.

Second, not every employee is aggressive to do feedback seeking behavior; the personality may affect their behavior. Extroverted people are not shy to show their advantages or interact with other people. Extroversion or introversion personality may lead to different ability to do feedback seeking behavior. Therefore, in this paper, we seek to understand the extent which personality influence the good and bad feedback seeking behavior.

Third, some supervisors are task-oriented; they ask subordinates to accomplish the job without excuses. Some supervisors are human-oriented, they care every subordinate not only their working performance but also themselves. Subordinates may know the effect of using feedback seeking behavior to influence task-oriented or human-oriented supervisors is different. They may display distinct feedback seeking behavior to different management style supervisors. Consequently, our final purpose is to examine will different management style supervisors moderate the relationship between subordinates’ personality and feedback seeking behavior.

Theoretical Background

Feedback Seeking Behavior and Impression Management

Previous research of feedback focused on how supervisor conveys a message to a subordinate (Ilgen, Fisher and Taylor, 1979) [9]. Therefore, Ashford and Cummings (1983) [3] propose a new thinking that subordinates may proactively seek feedback in stead of passively waiting for it to be informed. Because subordinates would like to know how their working performance have been perceived by supervisors and what should they do to deal with their job, they would ask others, such as supervisors or coworkers for information about their performance (Ashford and Cummings, 1983, 1985) [3] [4]. This kind of behavior is defined as feedback seeking.

By proactive feedback seeking behavior, subordinates not
only obtain useful working information from their supervisors, confirm supervisors’ perception of their level of working performance in advance, but also can influence their impression (Morrison and Bies, 1991) [12]. These motives would be driven subordinates to seek feedback aggressively. When subordinates performed well, proactive good feedback seeking behavior attract supervisors’ attention on their success working performance, ensure supervisors perceived their completion of a task and even to increase the supervisors’ perceptions of their working quality. Further, they can get job praise, money reward or promotion; subordinates are more willing to exhibit good feedback seeking behavior.

When subordinates performed poorly, aggressive bad feedback seeking behavior can help them acquire more remedy information from supervisors, give them adequate apologies and excuses to reduce supervisors’ angry and negative evaluation. Therefore, subordinates may avoid inflicting the punishment, penalty and loss supervisors’ trust of working ability; subordinates will tend to display bad feedback seeking behavior.

**Chinese Culture and Feedback Seeking Behavior**

Culture plays an important role in directing persons’ social skills and communication. Taiwan is strongly influenced in many aspects by traditional Chinese culture and Confucian values. Chinese culture values include harmony, conformity and “face” (Raltson et al., 1993; Shaw et al., 1993) [15][17]. In Hofstede (1988) [8] study, Taiwan society compared to U.S. culture is at the lower middle end of the Individualism scale. Under the influence of collectivism (not too outstanding of their coworkers) and humble, when subordinates performed well, they may not aggressive inquire supervisors’ feedback. Because of making a parade of successful working performance, it may damage their harmonious working relationships with coworkers. However, when they performed poorly, in order to avoid loss of “face”, they are more aggressive to do bad feedback seeking behavior and try to manipulate their supervisors’ impression to reduce their image harmed.

H1: Taiwanese subordinates are more aggressive to perform bad feedback seeking behavior than good feedback seeking behavior.

**Extraverted Person and Feedback Seeking Behavior**

Personal trait is continued and steady psychological condition that we can use it to predict persons how to interact with others. Some people are more aggressive and better than others to do impression management. According to Costa and McCrae (1992) [5], extraverted people are likely to be sociable, energetic, dominant, cheerful and positive in their outlook on life. In contrast, introverted people are more conservative, less outgoing and unsocial. Consequently, when extraverted people have good performance, they may not shy to exhibit their success achievement to others. When they do not accomplish supervisors’ desire, they may use some social skills and actively inquire supervisors’ opinions to reduce their working images harmed. Thus, extraversion subordinates present more good feedback seeking behavior than introversion subordinates; extraversion subordinates exhibit more bad feedback seeking behavior than introversion subordinates. We therefore test the following hypotheses:

H2a: Extraversion personality is positive related to good feedback seeking behavior.

H2b: Extraversion personality is positive related to bad feedback seeking behavior.

**The Moderating Role of Supervisors’ Management Style**

Different supervisors’ management style would affect subordinates to adopt distinct communication style and interaction pattern. In the Ohio State Leadership Studies defined two different management styles. Consideration leadership supervisors have been defined as they establish job relationships with subordinates based on mutual trust, respect for subordinates’ ideas, and consideration of their feelings. Accordingly, initiating structure leadership supervisors have been defined as structure supervisors and subordinate roles toward goal attainment (Fisher and Edwards, 1988) [7]. Penley and Hawkins (1985) [14] argue that consideration supervisors are more human-oriented leadership and heavily rely on relational aspects of communication, such as interpersonal concern and warm. Initiating structure supervisors are more task-oriented leadership and communication focus is the actual content of the information provided. Under consideration leadership, extraversion subordinates perceived doing impression management with their supervisors is more effective. Aggressive good feedback seeking behavior let supervisors notice their success working performance and have good impression on them. Proactive bad feedback seeking behavior mitigated subordinates’ error and supervisors may think they have tried hard to attain the goal and than reduce their negative evaluation and emotion from subordinates’ poor working performance.

However, under initiating structure leadership, extraversion subordinates observe doing impression management with their supervisors is more ineffective. When subordinates performed well, supervisors may think they just fulfill their job, they will not increase their perception of subordinates’ working performance. If subordinates do not performed well, proactive bad feedback seeking behavior can not influence initiating structure supervisors’ impression. Because they depend on subordinates’ real outcome to make judgments, bad feedback seeking behavior is ineffective. Therefore, we posit supervisors’ management style will moderate the relationship between subordinates’ personality and good/bad feedback seeking behavior, as shown in the following hypotheses.

H3a: The positive moderating effect of consideration supervisors between extraversion subordinates and good feedback seeking behavior is stronger than initiating structure supervisors

H3b: The positive moderating effect of consideration supervisors between extraversion subordinates and bad feedback seeking behavior is stronger than initiating structure supervisors

**METHOD**

**Sample and Data Collection**

The sample of this study was collected from Taiwan Top 1000 corporations. We random sampled 620 companies and mailed our questionnaires to human resource department and sales department. Of these, 118 were returned, resulting in a
response rate of 18 percent. However, because of eliminating the uncompleted data, only 111 samples were examined in this study. For these samples, 46.8 percent of members were male, 73.9 percent had a college education or above and 45.9 percent of members were from human resource department, others were from sales department.

Measures

Good feedback seeking behavior
Good feedback seeking behavior which we modified scale from Moss, Valenzi and Taggart (2003) [13]. For example, “I will display my excellent work for my coworkers and hope they might replay some positive remarks to my supervisor.” “I would cheerfully greet my supervisor hoping that this would lead to a conversation about a task that I had effectively completed.” “After performing well, I would ask my supervisor about my performance to draw his/her attention to my success.” There are total were eight items, we summed these items. We averaged responses to these items (α=.74).

Bad feedback seeking behavior
Bad feedback seeking behavior which we modified scale from Moss, Valenzi and Taggart (2003) [13]. For example, “I would admit to my supervisor that I had performed poorly and tell him/her that I learned from the experience and would not repeat the incident.” “After performing poorly, I would show my supervisor that I was taking responsibility for my performance and taking corrective measures.” “I would inform my supervisor immediately after performing poorly and tell/guarantee/promise him/her that I would do an excellent job the next time.” Total were eight items, we summed these items. We averaged responses to these items (α=.65).

Extraversion personality
Employees’ extraversion personality which we modified scale from NEO PI-R(S form) (Costa and McCrae,1991) [5]. For example, “I always feel full of energy.” “I like to talk with others.” Total were five items, we summed these items. The higher scores called extraversion person and lower scores called introversion person. We averaged responses to these items (α=.69).

Initiating structure leadership
Initiating structure which we modified scale from the research of Stogdill (1963) [18]. For example, “Supervisor requests his employees to obey his working rules.” “Supervisor clearly notifies every employee know his working requirement” Total were ten items, we summed these items. The higher scores called high initiating structure supervisor and lower scores called low initiating structure supervisor. We averaged responses to these items (α=.78).

Consideration leadership
Consideration which we also modified scale from the research of Stogdill (1963) [18]. For example, “Supervisor respects his employees’ welfare.” “Supervisor is glad to accept employees’ opinions and feelings” Total were ten items, we summed these items. The higher scores called high consideration supervisor and lower scores called low consideration supervisor. We averaged responses to these items (α=.89).

RESULTS

Descriptive Statistics

TABLE 1 presents the means standard deviations and zero-order Pearson correlations of all the key variables. (As show in TABLE 1)

Tests of the Hypotheses

Good and back feedback seeking behavior
Taiwanese employees tended to exhibit more bad feedback seeking behavior (M=6.56, SD=1.51) than good feedback seeking behavior (M=4.55, SD=4.52, t(110)= 8.785, p<.000) to their supervisors. Hypothesis 1 was supported.

Main effect and moderating effect
We conducted a hierarchical multiple regression to test Hypothesis 2a, 2b, 3a and 3b. As shown in Table 2, after regressing Good/Bad feedback seeking behavior on the extraversion personality, extraversion personality was positive related to good feedback seeking behavior (β=0.183, p<0.05), lending support to Hypothesis 2a; positive related to bad feedback seeking behavior(β=0.168, p<.1< p=0.1) Hypothesis 2b was supported.

TABLE 1 Means, Standard Deviations, Correlations, and Reliabilities

<table>
<thead>
<tr>
<th>Key Variables</th>
<th>Mean</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extraversion</td>
<td>3.67</td>
<td>.56</td>
</tr>
<tr>
<td>Initiating structure</td>
<td>3.32</td>
<td>.57</td>
</tr>
<tr>
<td>Consideration</td>
<td>3.18</td>
<td>.73</td>
</tr>
<tr>
<td>Good FSB</td>
<td>4.52</td>
<td>1.99</td>
</tr>
<tr>
<td>Bad FSB</td>
<td>6.56</td>
<td>1.52</td>
</tr>
</tbody>
</table>

n=111, p < .1, *p< .05, **P< .01

TABLE 2 shows that the supervisors’ management style of initiating structure (β=0.017, p=0.173) and consideration (β=0.005, p=0.961) does not moderate the link between extraversion personality and good feedback seeking behavior, and Hypothesis 3a was not supported. The probably reason is that Chinese culture influence Taiwanese employees exhibited fewer good feedback seeking behavior despite facing different management style. Initiating structure (β=0.078, p=0.533) does not moderate the link between extraversion personality and bad feedback seeking behavior, however, consideration (β=0.287, p=0.01) significant moderate the link between extraversion personality and bad feedback seeking behavior, and Hypothesis 3b was supported.
TABLE 2 Results of Regression Analysis for Interactive Effect of Extraversion Personality and Supervisors’ Management Style on Good/Bad Feedback Seeking Behavior

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Good FSB</th>
<th>Bad FSB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extraversion</td>
<td>0.183</td>
<td>0.168</td>
</tr>
<tr>
<td>Interactive effects</td>
<td>1.943**</td>
<td>1.784*</td>
</tr>
<tr>
<td>Extraversion × Initiating structure</td>
<td>0.017</td>
<td>0.078</td>
</tr>
<tr>
<td>Extraversion × Consideration</td>
<td>1.372</td>
<td>0.625</td>
</tr>
<tr>
<td></td>
<td>0.005</td>
<td>2.624***</td>
</tr>
<tr>
<td></td>
<td>0.049</td>
<td></td>
</tr>
</tbody>
</table>

n=111, * p < .1, **p < .05, ***p < .01

GENERAL DISCUSSION

This paper had three important goals. First, Taiwanese subordinates are indeed shy to exhibit good feedback seeking behavior let supervisors know their achievement. When they failed to complete the goal, they are more aggressive to influence supervisors’ judgment. From a practical standpoint, this finding is the important management implication for multinational corporations or company with different culture background employees. They should concern different culture value directing employees’ organization behavior. Corporations should design a fair evaluation performance appraisal system.

Second, our research result finds that extraversion employees present more feedback seeking behavior. Past literatures put less emphasis on the effect of different personality (Ashford and Cummings, 1983; Moss, Valenzi and Taggart, 2003) [3] [13]. The practical implication for managers is that they should appraise performance carefully, and avoid these kinds of impression management distorting true working performance.

Third, this paper present consideration supervisors’ management style positively moderated the relationship between extraversion personality and bad feedback seeking behavior. Under the consideration management style, employees do more feedback seeking behavior to mitigate punishment of job failure and influence supervisors’ impression. This finding complete some part of feedback literature, and also remind consideration supervisor not to be manipulated by extraversion subordinate’s bad feed seeking behavior.

Limitations and Future Research

Like any study, this one is not without limitations. First, our research relies on all self-report assessment that some relationship might be inflated by common-method variance. Therefore, we believe common-method variance is not a major threat in our research but indeed is a research limitation. Future researcher might examine these effects by collecting information from different sources (e.g. supervisors).

Second, the current research is also limited by its cross-section design; our study could be extended by using a longitudinal research design to clarify how feedback seeking behavior affect performance appraisal. In spite of the limitation of our research, our findings provide new insights of feedback seeking behavior. We also encourage researchers to conduct other relative variable (e.g. LMX quality, (Liden et al., 1997) [11]). This is an interesting area for future research.

REFERENCE


Optimal Replenishment Policy to Mitigate Hi-Tech Products Risks Under Declining Market

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H. M. Wee, Chung Yuan Christian University, Taiwan, weehm@cycu.edu.tw

Abstract

The risks on supply chain have increased continuously in recent years. One such risk for Hi-tech products is the result of rapid technological innovation which results in a significant decline in the component cost, the selling price and the demand (due to newer products introduction). The Hi-tech products include computers and communication consumer’s products. From a practical standpoint, a more realistic replenishment policy is needed to consider the impact of the risk, especially when the shortage is partially backordered. In this paper, an economic lot size model with partial backordering in a finite planning horizon is developed for a buyer when the component cost, the selling price, and the demand rate to the end-consumer decline at a continuous rate. A numerical example is provided to illustrate two replenishment models with fixed and varying replenishment intervals. Sensitivity analysis is carried out to investigate the relationship between the decision variables and some important parameters.

Keywords: Hi-tech products; innovation; replenishment policy; risks; partial backordering

1. Introduction

Hi-tech products have the following characteristics: shorter product life cycle time, quicker responsive time, increasing need for globalization and massive customization. Moreover, the component cost, the selling price and demand rate usually decrease with time due to global recession and technological innovation. In some Hi-tech industries such as computers and communication consumer products, some component costs and selling prices are declining at about 1% per week [1]. This implies that purchasing or selling one-week earlier or later will result in about 1% loss. Lee [2] has made some comments on the importance of the above subject.


In this paper, a replenishment policy with finite planning horizon is developed for a buyer when the component cost, the demand rate and the selling price to the end-consumer decline at a continuous rate. Two cases of fixed and varying replenishment intervals are considered. Two mathematical models and its solution procedure are developed in the next two sections. A numerical example is then provided to demonstrate the difference between the two cases. Sensitivity analysis is carried out to derive the sensitivity for the net profit of some important parameters. The concluding remark is given in the last section.

2. Mathematical modeling and analysis

The mathematical model in this paper is developed on the basis of the following assumptions:
(a) The replenishment rate is instantaneous.
(b) Component cost and product selling price to the end consumer decline at a continuous rate per unit time.
(c) Demand rate is continuous and exponentially decreasing.
(d) Entire planning horizon is finite.
(e) Two cases of both identical and different replenishment intervals are considered.
(f) Shortages are allowed except for the initial and final cycles.
(g) A fraction of the shortages is backlogged while the rest is lost sale.
(h) Purchase lead-time is constant.
(i) The order quantity, inventory level and demand are treated as continuous variables, and the number of replenishment is treated as discrete variable.

The decision variables are:

- \( n \) integral number of orders in the entire planning horizon \( T \), replenishment time during \( i^{th} \) cycle, \( i = 1, 2, \ldots, n \)
- \( t_i \) time point when the inventory level of \( i^{th} \) cycle drops to zero
- \( T \) replenishment interval for the case of identical replenishment interval
- \( r \) a fraction in each replenishment cycle with stocks, defined as service level

The other related parameters are as follows:
- \( d(t) \) annual demand rate, where \( d(t) = a \exp(-bt) \), \( a \) is the scale parameter and \( b \) is the sensitive parameter of demand.
C(t) unit component cost, where \( C(t) = C_0(1-r)^t \), \( C_0 \) is the unit component cost when \( t=0 \), \( r \) is the annual decline-rate of component cost.

\( S(t) \) unit selling price, where \( S(t) = S_0(1-r)^t \), \( S_0 \) is the unit selling price when \( t=0 \), \( r \) is the annual decline-rate of selling price to the end-consumer.

\( H \) length of the planning horizon by year

\( C_1 \) ordering cost per order

\( C_2 \) holding cost per unit per year

\( C_3 \) backlogged shortage cost per unit per year

\( C_4 \) lost sale shortage penalty cost per unit

\( B \) fraction of shortages backordered

\( NP \) net profit in the planning horizon

![Graphical representation of inventory system with decreasing demand](image)

Figure 1. A graphical representation of inventory system with decreasing demand

A graphical representation of inventory system with decreasing demand is depicted in Figure 1. Without loss of generality, \( T_{r,i} = (i=1,2,\ldots,n) \) are the replenishment times over the entire period \( H \). Initial time \( T_0 = 0 \) and final time \( T_n = H \) inventories are both zero. Inventory in \( i \)th cycle drops to zero at time \( t_i \) \( (i=1,2,\ldots,n) \). The purpose of this problem is to obtain optimal values of \( n, r \) and \( T_{r,i} \) such that the total net profit over the finite horizon is a maximum value.

**Case A. For Fixed replenishment interval**

For the case of fixed replenishment interval, the replenishment time can be expressed as

\[
T = \frac{H}{n}
\]

Since stock is depleted by demand, the differential equations of inventory levels during time intervals \( [(i-1)T,(i-1+r)T] \) and \( [(i-1+r)T,iT] \) are

\[
\frac{dI(t)}{dt} = -ae^{-rt}, \quad (i-1)T \leq t \leq (i-1+r)T
\]

and

\[
\frac{dI(t)}{dt} = -Bae^{-rt}, \quad (i-1+r)T \leq t \leq iT
\]

respectively.

Using the boundary condition \( I(t)=0 \) when \( t=(i-1+r)T \), the inventory levels during time intervals \( [(i-1)T,(i-1+r)T] \) and \( [(i-1+r)T,iT] \) are

\[
I(t) = \frac{a}{b}(e^{-rt} - e^{-b(i-1+r)T}), \quad (i-1)T \leq t \leq (i-1+r)T
\]

and

\[
I(t) = \frac{B}{b}(e^{-rt} - e^{-b(i-1+r)T}), \quad (i-1+r)T \leq t \leq iT
\]

respectively.

The lot size during \( i \)th cycle, \( Q_i \), when \( t=(i-1)T \), is the filled demand during time interval \( [(i-1)T,(i-1+r)T] \). It is expressed as follows:

\[
Q_i = \frac{b}{a} \int_{(i-1)T}^{(i-1+r)T} e^{rt} \, dt + \int_{(i-1+r)T}^{iT} ae^{-rt} \, dt, \quad i=1,2,\ldots,n-1
\]

The initial and final lot sizes are

\[
Q_0 = \frac{b}{a} \int_0^{(i-1)T} e^{rt} \, dt, \quad Q_n = \frac{b}{a} \int_{iT}^{H} ae^{-rt} \, dt
\]

During \( i \)th cycle, the annual holding cost per unit cost is assumed as a constant value \( C_3 \), the time-weighted inventory is

\[
\sum_{t=(i-1)T}^{iT} I(t) \quad \text{during time interval} \quad [(i-1)T,(i-1+r)T]
\]

and the holding cost, \( HC_i \) is

\[
HC_i = C_3 \int_{(i-1)T}^{iT} I(t) \, dt, \quad i=1,2,\ldots,n-1
\]

In the entire horizon, the holding cost is

\[
HC = \sum_{i=1}^{n} HC_i + C_3 \int_{iT}^{H} I(t) \, dt
\]

During \( i \)th cycle, the annual backordering cost per unit is assumed as a constant value \( C_3 \), the time-weighted shortage is

\[
\sum_{t=(i-1)T}^{iT} I(t) \quad \text{during time interval} \quad [(i-1)T,(i-1+r)T]
\]

and the backordering cost, \( BC_i \) is

\[
BC_i = -C_3 \int_{(i-1)T}^{iT} I(t) \, dt
\]

In the entire horizon, the backordering cost is

\[
BC = \sum_{i=1}^{n} BC_i
\]

During \( i \)th cycle, the lost sale penalty cost, \( LC_i \) is the unfilled demand during time interval \( [(i-1)T,(i-1+r)T] \). That is

\[
LC_i = C_4(1-B) \int_{(i-1)T}^{iT} I(t) \, dt
\]

In the entire horizon, the lost sale cost is

\[
LC = \sum_{i=1}^{n} LC_i
\]

The component purchase cost during \( i \)th cycle, \( PC_i \) is the product of \( Q_i \) and unit component cost \( C_0(1-r)^t \) at \( t=(i-1)T \). One has

\[
PC_i = Q_i C_0(1-r)^t, \quad i=1,2,\ldots,n
\]

In the entire horizon, the purchase cost is

\[
PC = \sum_{i=1}^{n} PC_i
\]

The sales revenue during \( i \)th cycle, \( SR_i \) is the integration of the product of the unit selling price and the filled demand
quantity. One has

$$SR = \sum_{i=1}^{n} \int_{T_{i-1}}^{T_{i}} S(t) d(t) dt + \int_{T_{n}}^{T} S(t) d(t) dt$$

(11)

In the entire horizon, the sales revenue is

$$SR = \sum_{i=1}^{n} SR_i + \int_{T_{n}}^{T} S(t) d(t) dt$$

The net profit, \( NP \) is expressed as:

$$NP(n, r) = SR - HC - BC - LC - PC - nC_i$$

Subject to (1) and \( 0 \leq r \leq 1 \)

In (12), the term \( nC_i \) is the setup cost in the entire horizon.

Using transformation from (1) for fixed replenishment interval, the net profit function in (12) has two independent decision variables: \( n \) and \( r \).

**Case B. For varying replenishment interval**

For the case of varying replenishment interval, the relation among \( t_i, \ T_{i-1} \) and \( T_{i} \) is

$$t_i = (1-r)T_{i-1} + rT_{i}, \ i = 1, 2, \ldots n-1$$

(13)

where the final value is \( t_n = H \).

Since stock is depleted by demand, the differential equations of inventory levels during time intervals \([T_{i-1}, T_i]\) and \([T_i, T_{i+1}]\) are

$$\frac{dI(t)}{dt} = -ae^{-bt}, \ T_{i-1} \leq t \leq t_i$$

(14)

and

$$\frac{dI(t)}{dt} = -Bae^{-bt}, \ t_i \leq t \leq T_i$$

(15)

respectively.

Using the boundary condition \( I(t) = 0 \) when \( t = t_i \), the inventory levels during time intervals \([T_{i-1}, t_i]\) and \([T_i, T_{i+1}]\) are

$$I(t) = \frac{a}{b} (e^{-bt} - e^{-bt_i}), \ T_{i-1} \leq t \leq t_i$$

(16)

and

$$I(t) = \frac{ab}{b} (e^{-bt_i} - e^{-bt}), \ t_i \leq t \leq T_i$$

(17)

respectively.

The lot size during \( i \)th cycle, \( Q_{i-1} \) when \( t = T_{i-1} \), is the filled demand during time interval \([T_{i-1}, t_i]\). It is expressed as follows:

$$Q_{i-1} = B \int_{T_{i-1}}^{T_{i}} ae^{-bt} dt + \int_{T_{i-1}}^{T_{i}} ae^{-bt} dt, i = 2, 3, \ldots n-1$$

(18)

The initial and final lot sizes are \( Q_0 = \int_{0}^{T_{i}} ae^{-bt} dt \) and

$$Q_{i} = B \int_{T_{i-1}}^{T_{i}} ae^{-bt} dt + \int_{T_{i-1}}^{T_{i}} ae^{-bt} dt$$

respectively.

During \( i \)th cycle, the annual holding cost per unit cost is assumed as a constant value \( C_2 \), the time-weighted inventory is \( \int_{T_{i-1}}^{T_i} I(t) dt \) during time interval \([T_{i-1}, T_i]\), and the holding cost, \( HC_i \) is

$$HC_i = C_2 \int_{T_{i-1}}^{T_i} I(t) dt, i = 1, 2, \ldots n-1$$

(19)

In the entire horizon, the holding cost is

$$HC = \sum_{i=1}^{n} HC_i$$

During \( i \)th cycle, the annual backordering cost per unit is assumed as a constant value \( C_3 \), the time-weighted shortage is \( \int_{t_i}^{T_i} I(t) dt \) during time interval \([t_i, T_i]\), the backordering shortage cost, \( BC_i \) is

$$BC_i = -C_3 \int_{t_i}^{T_i} I(t) dt$$

(20)

In the entire horizon, the backordering cost is

$$BC = \sum_{i=1}^{n} BC_i$$

During \( i \)th cycle, the lost sale penalty cost, \( LC_i \) is the unfilled demand during time interval \([t_i, T_i]\). That is

$$LC_i = C_4 (1 - r_i) \int_{t_i}^{T_i} d(t) dt$$

(21)

In the entire horizon, the lost sale penalty cost is

$$LC = \sum_{i=1}^{n} LC_i$$

The component purchase cost during \( i \)th cycle, \( PC_i \) is the product of \( Q_{i-1} \) and unit component cost \( C_0 (1 - r_i)^\gamma \) at \( t = T_{i-1} \). One has

$$PC_i = Q_{i-1} C_0 (1 - r_i)^\gamma$$

(22)

In the whole horizon, the purchase cost is

$$PC = \sum_{i=1}^{n} PC_i$$

The sales revenue during \( i \)th cycle, \( SR_i \) is the integration of the product of the unit selling price and the filled demand quantity. One has

$$SR_i = \int_{T_{i-1}}^{T_i} S(t) d(t) dt + B \int_{T_{i-1}}^{T_i} S(t) d(t) dt, i = 1, 2, \ldots n-1$$

(23)

$$SR = \sum_{i=1}^{n} SR_i + \int_{T_{n}}^{T} S(t) d(t) dt$$

The net profit, \( NP \) is expressed as:

$$NP(n, r; T_i) = SR - HC - BC - LC - PC - nC_i$$

Subject to (13) and \( 0 \leq r \leq 1 \)

Using transformation from (13) for varying replenishment interval, there are \( n+1 \) independent decision variables: \( n, r \) and \( T_i \), where \( i = 1, 2, \ldots n-1 \).
3. Solution procedure

Our aim is to derive the optimal values of the decision variables and maximize the total net profit in the entire planning horizon.

Case A. For fixed replenishment interval

The solution procedure is as follows:

Step 1. Let \( n \) be a fixed positive integer.

Step 2. Equate the first derivatives of \( NP \) in (12), denoted by \( NP(r) \), with respect to \( r \) to zero and solve the \( r \) value.

Check for concavity. The sufficient optimality condition for maximizing \( NP(r) \) is

\[
\frac{d^2NP(r)}{dr^2} < 0
\]

(i) If \( r > 1 \) (example in Figure 2 and 3), let \( r = 1 \), then calculate \( NP \) in (12).

(ii) If \( r < 0 \) (example in Figure 4 and 5), let \( r = 0 \), then calculate \( NP \) in (12).

(iii) If \( 0 \leq r \leq 1 \) (example in Figure 6 and 7), then calculate \( NP \) in (12).

Step 3. Repeat Step 1 to Step 2 by assuming different positive integer values of \( n \). The optimal solution \( (n^*, r) \) must satisfy the following condition:

\[
NP(n^* - 1, r) \leq NP(n^*, r) \geq NP(n^* + 1, r) \tag{25}
\]

Case B. For varying replenishment interval

The solution procedure is as follows:

Step 1. Let the optimal value of Case A as the starting value of \( n \). The net profit (24), denoted by \( NP(T_i, T_{i+1}, r)^* \) has \( n \) decision variables with known \( n \) and \( T_i = H \).

Step 2. Equate the first partial derivatives of the net profit (24) with respect to \( T_i \) and \( r \) to zero as follows:

\[
\frac{\partial NP(T_i, T_{i+1}, r)}{\partial T_i} = 0, \quad i = 1, 2, \ldots, n - 1 \tag{26}
\]

and

\[
\frac{\partial NP(T_i, T_{i+1}, r)}{\partial r} = 0 \tag{27}
\]

Step 3. Solve \( (T_i, T_{i+1}, r) \) by using the \( n \) simultaneous equations from (26) and (27).

(i) If \( r > 1 \), let \( r = 1 \). Derive \( T_i \) and \( NP \) by solving the following \( n - 1 \) simultaneous equations:

\[
\frac{\partial NP(T_i, T_{i+1}, r)}{\partial T_i} = 0, \quad i = 1, 2, \ldots, n - 1 \tag{28}
\]

(ii) If \( r < 0 \), let \( r = 0 \). Derive \( T_i \) and \( NP \) by solving the \( n - 1 \) simultaneous equations in (28).

(iii) If \( 0 \leq r \leq 1 \), calculate \( NP \).

Step 4. Repeat Step 1 through Step 3 by different values of \( n \). The optimal value of \( n \), denoted by \( n^* \), must satisfy the following condition:

\[
NP(T_{10}, T_{11}, r^*) - NP(T_n, T_{n+1}, r^*) \geq NP(T_i, T_{i+1}, r^*) \tag{29}
\]

4. A numerical example

The preceding theory can be illustrated by the following numerical example. The parameters are given as follows:

- Unit component cost, \( C = C_0(1 - r)^r \), where \( C_0 = \$200 \) and \( r = 0.4 \) per year (approximately, \( r = 0.01 \) per week);
- Unit selling price, \( S = S_0(1 - r)^r \), where \( S_0 = \$400 \) and \( r = 0.4 \) per year; Entire Planning horizon considered, \( H = 4 \) years;
- Demand rate, \( d(t) = a \exp(-bt) \), \( 0 \leq t \leq H \), \( a = 200 \), \( b = 0.1 \); Ordering cost per order, \( C_O = \$400 \); Holding cost per unit per year, \( C_H = 40 \); Backlogging cost per unit per year,
C=80; Lost sale penalty cost. Per unit, Cc=120; Fraction of shortages backordered, B=0.9. Applying the solution procedure, the computational results are given as follows:

For Case A and B, the optimal replenishment times are both 17 in the planning horizon of 4 years. The net profits are $46,255 and $46,531. The percentage of net profit increase (PNPI) between Case A and Case B is defined as:

\[ \text{PNPI} = \left( \frac{\text{NP when (rc, rs)}}{\text{NP for Case A}} - 1 \right) \times 100\% \]

From Table 1 and Figure 8, Case B’s net profit is larger than Case A’s net profit; the value of PNPI is +0.60%. However, the computational process for Case A is easier than that for Case B.

The values for 17 replenishment cycles are shown in Table 2. With identical replenishment intervals in Case A, the lot size decreases with time due to decreasing demand. For Case B, the lot size increases with time because the effect of increasing replenishment time interval counteracts the effect of decreasing demand.

Table 1. Net profit with various replenishment times for Case A & B

<table>
<thead>
<tr>
<th>n</th>
<th>NP for Case A</th>
<th>NP for Case B</th>
<th>NP for Case A &amp; B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>46,255</td>
<td>46,255</td>
<td>46,255</td>
</tr>
<tr>
<td>2</td>
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<td>46,255</td>
<td>46,255</td>
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<tr>
<td>3</td>
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<td>46,255</td>
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</tr>
<tr>
<td>4</td>
<td>46,255</td>
<td>46,255</td>
<td>46,255</td>
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<tr>
<td>5</td>
<td>46,255</td>
<td>46,255</td>
<td>46,255</td>
</tr>
<tr>
<td>6</td>
<td>46,255</td>
<td>46,255</td>
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</tr>
<tr>
<td>7</td>
<td>46,255</td>
<td>46,255</td>
<td>46,255</td>
</tr>
<tr>
<td>8</td>
<td>46,255</td>
<td>46,255</td>
<td>46,255</td>
</tr>
<tr>
<td>9</td>
<td>46,255</td>
<td>46,255</td>
<td>46,255</td>
</tr>
<tr>
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<td>46,255</td>
<td>46,255</td>
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<tr>
<td>11</td>
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<td>46,255</td>
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<td>12</td>
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<td>46,255</td>
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<tr>
<td>16</td>
<td>46,255</td>
<td>46,255</td>
<td>46,255</td>
</tr>
<tr>
<td>17</td>
<td>46,255</td>
<td>46,255</td>
<td>46,255</td>
</tr>
</tbody>
</table>

Note: * Optimal solution

Figure 8. Net Profit with various n for Case A & B

Table 2. Results of the optimal replenishment cycles for Case A & B

<table>
<thead>
<tr>
<th>n</th>
<th>Case A</th>
<th>Case B</th>
<th>P</th>
<th>Rate (rc, rs)</th>
<th>Lc</th>
<th>Lr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.7591</td>
<td>0.7591</td>
<td>18</td>
<td>0.7591</td>
<td>24.5</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>0.7591</td>
<td>0.7591</td>
<td>18</td>
<td>0.7591</td>
<td>24.5</td>
<td>18</td>
</tr>
<tr>
<td>3</td>
<td>0.7591</td>
<td>0.7591</td>
<td>18</td>
<td>0.7591</td>
<td>24.5</td>
<td>18</td>
</tr>
<tr>
<td>4</td>
<td>0.7591</td>
<td>0.7591</td>
<td>18</td>
<td>0.7591</td>
<td>24.5</td>
<td>18</td>
</tr>
<tr>
<td>5</td>
<td>0.7591</td>
<td>0.7591</td>
<td>18</td>
<td>0.7591</td>
<td>24.5</td>
<td>18</td>
</tr>
<tr>
<td>6</td>
<td>0.7591</td>
<td>0.7591</td>
<td>18</td>
<td>0.7591</td>
<td>24.5</td>
<td>18</td>
</tr>
<tr>
<td>7</td>
<td>0.7591</td>
<td>0.7591</td>
<td>18</td>
<td>0.7591</td>
<td>24.5</td>
<td>18</td>
</tr>
<tr>
<td>8</td>
<td>0.7591</td>
<td>0.7591</td>
<td>18</td>
<td>0.7591</td>
<td>24.5</td>
<td>18</td>
</tr>
<tr>
<td>9</td>
<td>0.7591</td>
<td>0.7591</td>
<td>18</td>
<td>0.7591</td>
<td>24.5</td>
<td>18</td>
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<tr>
<td>10</td>
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<td>24.5</td>
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<td>11</td>
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<td>18</td>
<td>0.7591</td>
<td>24.5</td>
<td>18</td>
</tr>
</tbody>
</table>

5. Sensitivity analysis

If there exists decline-rates of component cost and product selling price, the net profits when \((rc, rs)\) is considered compared with that when \((rc, rs)\) is ignored are shown in Table 3. When the value of \((rc, rs)\) increases from the basic value of 0.4 to \([-5\%], \[+10\%\] and \[-15\%\], the percentage of net profit increase (PNPI) is derived. The range of PNPI value is from 2.13% to 4.06%. Since the PNPI is significant, the changes of \((rc, rs)\) cannot be ignored. When decline-rates of \((rc, rs)\) do exist and is considered, the number of replenishment becomes larger to keep lower component purchase cost compared with that when \((rc, rs)\) is ignored. While, when the values of \((rc, rs)\) decrease, the number of replenishments become larger to reduce the purchase and shortage costs.

Table 3. PNPI when \((rc, rs)\) is considered for identical replenishment interval (B=0.9)

<table>
<thead>
<tr>
<th>(n)</th>
<th>(\text{PNPI}) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.71</td>
</tr>
<tr>
<td>2</td>
<td>0.71</td>
</tr>
<tr>
<td>3</td>
<td>0.71</td>
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<tr>
<td>4</td>
<td>0.71</td>
</tr>
<tr>
<td>5</td>
<td>0.71</td>
</tr>
<tr>
<td>6</td>
<td>0.71</td>
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<tr>
<td>7</td>
<td>0.71</td>
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<tr>
<td>8</td>
<td>0.71</td>
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<tr>
<td>9</td>
<td>0.71</td>
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<td>10</td>
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<td>11</td>
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<td>15</td>
<td>0.71</td>
</tr>
<tr>
<td>16</td>
<td>0.71</td>
</tr>
<tr>
<td>17</td>
<td>0.71</td>
</tr>
</tbody>
</table>

Note: PNPI = [NP when \((rc, rs)\) is considered - NP when \((rc, rs)\) is ignored] / NP when \((rc, rs)\) is ignored

Optimal solutions for various \(B\) values ranging from 0 to 1 are shown in Table 4. The following observations are made from the results of the analysis:

1. Under the condition of perfect competition \((B=0)\), the optimal service level is 1 to reduce shortage cost.
2. Under the condition of monopoly, the optimal service level and the number of replenishments are much lower since the shortages can be backlogged completely. When the value of decreases, the service level increases to reduce shortage cost.
3. In order to keep the service level high, lot size and holding cost must increase.
4. The higher service level, the more the number of replenishment. It makes sense that JIT deliveries increase service level.
5. In perfect competition, the number of replenishments is large and the service level maintains at100% to reduce shortage.
6. In monopoly, since the shortage will be backordered completely, the service level maintains lower and the number of replenishments is less.
7. When \(B\leq0.9\) (the lower bound of \(B\)) the optimal solution is to allow no shortage (i.e., \(r=1\)); this is due to higher shortage cost. An iterative approach to derive the value of the lower bound of \(B\) is described in Appendix A.
Table 4. Optimal solutions for various $B$ values with identical replenishment interval

<table>
<thead>
<tr>
<th>$B$</th>
<th>0</th>
<th>0.1</th>
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<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>1.0</th>
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<tr>
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<td>2.5</td>
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</tr>
<tr>
<td>$r$</td>
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<td>0.1</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
<td>0.5</td>
<td>1.0</td>
</tr>
</tbody>
</table>

6. Concluding remarks

Models with partially backordered for fixed (i.e., Case A) and varying (i.e., Case B) replenishment intervals are developed to consider the risk of decreasing component cost, selling price and demand rate. The solution of Case A is sub-optimal, and Case B is optimal. The percentage of net profit increase is approximately 0.60%. However, the solution procedure and the computational process of Case A are easier than that of Case B.

If the component cost decline-rate decreases, the service level increases. It results in more frequent deliveries and less purchase cost. If the selling price decline-rate decreases, the service level increases. It results in more frequent deliveries and less shortage cost. This study provides managerial insights to inventory practitioners in their replenishment planning.

In this study, the basic assumptions are instantaneous replenishment rate, exponentially decreasing demand, allowed shortage, and constant purchase lead time. For the case of finite replenishment rate, other patterns of varying demand and varying purchase lead time are left for further research.

References


Appendix A. Search of lower bound of $B$ value

The procedure of searching the lower of $B$ is as follows:

Step 1. Set initial value $B=1$.
Step 2. Let $n$ be a fixed value.
Step 3. Equate the first derivative of $NP(r, B)$ with respect to $r$ to zero and solve $r$. Check for concavity. The sufficient optimality condition for maximizing $NP(r, B)$ is

$$d^2NP(r, B) < 0$$

(i) If $r > 1$, let $r = 1$. Calculate NP in (12).
(ii) If $r < 0$, let $r = 0$. Calculate NP in (12).
(iii) If $0 \leq r \leq 1$, Calculate NP in (12).

Step 4. Repeat Step 2 through Step 3 by different values of $n$ until the following condition is satisfied.

$$NP(n + \frac{1}{B}, B) \geq NP(n, B) \geq NP(n - \frac{1}{B}, B)$$

Step 5. Decrease the value of $B$. Repeat Step 2 through Step 4.

The lower bound of $B$ occurs at the least value of $B$ that satisfies the sufficient optimality condition in Step 3. When the actual fraction of $B$ is not larger than the lower bound, no shortage is allowed (i.e., $r = 1$).
Collaborative Vendor-Buyer Model With Stochastic Demand

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Abstract

This study develops a collaborative vendor-buyer model with stochastic demand. An optimal replenishing and pricing policy for each of the three scenarios is derived. The first scenario does not consider collaboration and price discount. The second scenario considers collaboration without price discount. The last scenario considers both the collaboration and price discount. Since it usually benefits the vendor more than the buyer when the buyer and the vendor collaborate, a quantity discount pricing strategy is necessary to entice the buyer to accept the collaboration. A negotiation factor is incorporated to balance the profit sharing between both players. In addition, we have proved that the collaborative advantage is usually more significant when the demand mean value decreases or the standard deviation increases. A numerical example and sensitivity analysis are provided to validate the theory.

Keywords: Stochastic demands, collaboration, vendor-buyer model, replenishing and pricing strategy.

1. Introduction

Traditionally, the vendor and the buyer are two individual entities with different objectives and interests. Due to rising cost, globalization, shrinking resources, shortened product life cycles and the importance of quick responsive, increasing attention has been placed on the whole supply chains. An effective supply chain network requires a cooperative relationship between the vendor and the buyer. The cooperation includes the sharing of information, resources and profit. The result of close cooperation is a mutual beneficial environment which will increase the joint profit as well as enable a quicker respond to customer demand. One of the most common strategies is to setup an optimal replenishment and pricing policy acceptable to both the vendor and the buyer. These strategies may also include a better credit terms and price discount policy.

Monahan (1984) was one of the early authors who analyzed a vendor-oriented optimal quantity discount policy that maximized the vendor’s gain; it is done at no additional cost to the buyer. Lal and Staelin (1984) developed a fixed order quantity decision model with a discounting scheme to benefit the buyers. Lee and Rosenblatt (1986) generalized Monahan’s model and developed an algorithm to solve the vendor’s ordering and discount-pricing policy. Gallego and van Ryzin (1994) derived some models to deal with how a buyer decides the price of a product that can be sold only during a single period of time. Kim and Hwang (1998) derived an incremental discount-pricing schedule with multiple customers and single price break. Chakravarty and Martin (1988) developed a joint cost-sharing scheme between the seller and the buyers. An algorithm was developed to determine both the discount price and the replenishment interval for any desired negotiation factor. Weng and Wong (1993) developed a general all-unit quantity discount models to determine the optimal pricing and replenishment policy. Under the condition of price-sensitive demand, Weng (1995) later considered the vendor’s quantity discount from the perspective of reducing the vendor’s operating cost and increasing the buyer’s demand. Li et al. (1996) developed a lot-for-lot joint pricing policy with price-sensitive demand. Wee (1998) developed a lot-for-lot discount pricing policy for deteriorating items with constant demand rate. Emmons and Gilbert (1988) studied the effect of return policy on both the vendor and the buyer. Such policy is to maximize the vendor’s profit by inducing the buyer to place larger order when demand is uncertain. Shin and Benton (2007) developed supply chain coordination using quantity discount.

In this paper, a collaborative supply chain model with price discount is developed for a stochastic demand. A negotiation factor is incorporated to share the profit between both players. Numerical example and sensitivity analysis are carried out to show how the demand’s mean and the standard-deviation affect the joint expected profit.

2. Mathematical modeling and analysis

The mathematical model is developed on the basis of the following assumptions.

(a) The demand rate is uncertain with known probability density function
(b) A collaborative system of single-vendor and single-buyer is considered.
(c) The vendor and the buyer have complete knowledge of each other’s information.
(d) A fashion product like dress and catalogue product with single order period, short selling season and long production lead-time is considered.

The parameters are as follows:

\( Q_i \) Buyer’s order quantity for scenario \( i, i=1, 2, 3 \)
\( W_i \) Wholesale price paid by the buyer to the vendor for scenario \( i \)
\( R \) Retail price
\( f(x) \) Probability density function of uncertain demand \( x \)
\( S \) Unit shortage cost
\( V \) Salvage value for each unsold unit
\( C \) Vendor’s unit variable cost
\( K \) Vendor’s fixed cost per setup
\( EP_{pi} \) Buyer’s expected profit for scenario \( i \)
\( EP_{vi} \) Vendor’s expected profit for scenario \( i \)
\( EP_i \) Joint expected profit for scenario \( i \)
\( PEPI_i \) Percentage of joint expected profit increase comparing \( EP_i \) with \( EP \)
\( MP \) Marginal profit for each sold unit
\( ML \) Marginal lose for each unsold unit
\( \alpha \) Negotiation factor

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The model is shown in Figure 1.

Figure 1. The collaborative vendor-buyer system

Three scenarios are considered.

Scenario 1: Without considering the buyer-vendor collaboration and price reduction

From the viewpoint of the buyer, the buyer’s marginal profit and lose are \(R-W_1\) and \(W_1-V\) respectively. The buyer’s expected profit is

\[
EP_b = (R-W_1)Q_1 - \int_0^Q (Q_1 - x) f(x) dx - (W_1-V)\int_0^Q (Q_1 - x) f(x) dx
- S\int_0^Q (Q_1 - x) f(x) dx - K
\]

(1)

The first term in (1) is the sales gross profit, the second term is the unsold loses, and the last term is the shortage loses. Taking the first derivative of (1) with respect to \(Q_1\) and equating it to zero, one can derive the buyer’s optimal purchase quantity

\[
Q_1^* = F^{-1}(R-W_1+S) / (R-V+S)
\]

(2)

where \(F^{-1}\) is the reverse function of \(F(x)\) which is the cumulative distribution function of \(f(x)\). After \(Q_1\) is decided by the buyer, the vendor’s profit is

\[
EP_v = (W_1-C)Q_1^* - K
\]

(3)

The joint expected profit is the sum of (1) and (3).

\[
EP_1 = EP_{b1} + EP_{v1}
\]

(4)

Substituting (2) into (1), one can derive \(EP_1\). For scenario 1 without considering collaboration, the buyer and the vendor makes strategic decision independently.

Scenario 2: Considering the buyer-vendor collaboration without price reduction

The wholesale price is assumed as the same as that in scenario 1. From the viewpoint of the whole vendor-buyer system, the whole system’s marginal profit and lose are \(R-C\) and \(C-V\) respectively. The joint expected profit is

\[
EP_2 = (R-C)\int_0^Q (Q_1 - x) f(x) dx - (C-V)\int_0^Q (Q_1 - x) f(x) dx
- S\int_0^Q (Q_1 - x) f(x) dx - K
\]

(5)

Taking the first derivative of (5) with respect to \(Q_2\) and equating it to zero, one can derive the optimal joint purchase quantity

\[
Q_2^* = F^{-1}\left(\frac{R-C+S}{R-V+S}\right)
\]

(6)

The vendor’s and the buyer’s profits are

\[
EP_{v2} = (W_2-C)Q_2^* - K
\]

(7)

and

\[
EP_{b2} = EP_2 - EP_{v2}
\]

(8)

respectively. Substituting (6) into (5), one can derive \(EP_2\). For scenario 2, the buyer-vendor collaboration is considered. The joint expected profit is optimized jointly rather than independently as in scenario 1.

Scenario 3: Considering the collaboration and price reduction simultaneously

Since it usually benefits the vendor more than the buyer when both the buyer and the vendor are collaborated in scenario 2, a quantity discount pricing strategy is necessary to entice the buyer to accept the collaboration. In this scenario, the wholesale price is reduced to entice the buyer to join the collaboration. The joint expected profit is

\[
EP_3 = (R-C)\int_0^Q (Q_3 - x) f(x) dx - (C-V)\int_0^Q (Q_3 - x) f(x) dx
- S\int_0^Q (Q_3 - x) f(x) dx - K
\]

(9)

The optimal value of \(Q_3\) is the same as \(Q_2\). Since (9) is not a function of wholesale price, the optimal expected profit \(EP_3\) is the same as \(EP_2\). The buyer’s and the vendor’s extra benefits incurred from collaboration, \(\Delta_b\) and \(\Delta_v\), are defined as

\[
\Delta_b = EP_{b3} - EP_{b1}
\]

(10)

and

\[
\Delta_v = EP_{v3} - EP_{v1}
\]

(11)

respectively.

Incorporating the negotiation factor, the relationship between the buyer’s and the vendor’s extra benefit is defined as

\[
\Delta_v = \alpha \Delta_b
\]

(12)

where \(\alpha\) is the negotiation factor.

When \(\alpha = 0\), it means all extra benefit sharing is accrued to the buyer; when \(\alpha = 1\), it implies that the extra benefit sharing is equally distributed. A large \(\alpha\) means that benefit is
accrued mainly the vendor. The optimization problem is stated as:

Maximize \( EP_i \) 

Subject to \( \Delta_y = \alpha \Delta_y \)

From (12), one can derive \( W_i \) with known \( Q_i = F^{-1}\left(\frac{R-C+S}{R-V+S}\right) \). After substituting \( W_i \) and \( Q_i \) into the constraint of (13), one can derive \( W_j \) and \( EP_j \).

From (2) and (6), since \( W_i > C > V \), one can prove the following two propositions.

**PROPOSITION 1**

Collaborative order quantity is greater than non-collaborative order quantity.

Proof of PROPOSITION 1

From (6) and (2), \( Q_i > Q'_i \) because \( W_i > C \).

**PROPOSITION 2**

Collaborative joint expected profit is greater than non-collaborative joint expected profit.

Proof of PROPOSITION 2

Use the following transformations:

\[ \int_0^{Q_i} f(x)dx = F(Q_i) \]  

(14)

\[ \int_0^{Q_i} f(x)dx = \mu - \int_0^{Q_i} F(Q_i) + \int_0^{Q_i} F(x)dx \]  

(15)

\[ \int_0^{Q_i} \mu f(x)dx = Q_iF(Q_i) - \int_0^{Q_i} F(x)dx \]  

(16)

where \( \mu \) is the expected value of demand.

One can derive the difference between \( EP_2 \) and \( EP_1 \) from (5) and (4) as:

\[ EP_2 - EP_1 = (Q_2 - Q_1)(R - C + S) - (R - V + S) \int_0^{Q_i} F(x)dx \]  

(17)

The first derivative of (17) with respect to \( Q_2 \) is zero when \( Q_2 = F^{-1}\left(\frac{R-C+S}{R-V+S}\right) \) from (6). It is expressed as:

\[ \frac{d(EP_2 - EP_1)}{dQ_2} = (R-C+S) - (R-V+S)F(Q_2) = 0 \]  

(18)

The second derivative of (17) with respect to \( Q_2 \) is negative. It is expressed as:

\[ \frac{d(EP_2 - EP_1)^2}{dQ_2^2} = -(R-V+S)f(Q_2) < 0 \]  

(19)

Proposition 2 is proved because of the following reasons: (i) \( Q_i > Q'_i \) from Proposition 1, (ii) \( EP_2 - EP_1 = 0 \) if \( Q_2 = Q_1 \), (iii) The first derivative of (17) with respect to \( Q_2 \) is zero when \( Q_2 = F^{-1}\left(\frac{R-C+S}{R-V+S}\right) \) and (iv) The second derivative of (17) with respect to \( Q_2 \) is negative. The relation between \( (EP_2 - EP_1) \) and \( Q_2 \) is illustrated in Figure 2.

Figure 2. Relation between \((EP_2 - EP_1)\) and \( Q_2 \)

The percentage of expected profit increase (\( PEPI \)) is defined as

\[ PEPI_i = \frac{(EP_i - EP_1)}{EP_1} \times 100\%, \; i = 2, 3 \]  

(20)

**PROPOSITION 3**

The value of \( PEPI \) increases with respect to the vendor’s fixed cost.

Proof of PROPOSITION 3

\( EP_1 \) and \( EP_2 \) can be simplified as follow:

\[ EP_i = -(R-V+S) \int_0^{Q_i} F(x)dx + Q_i(R-C+S) - K - S\mu \]  

(21)

Taking the first derivative of \([(EP_2 - EP_1)/EP_1\)] with respect to the vendor’s fixed cost, one can derive

\[ \frac{d}{dK} \left( \frac{EP_2}{EP_1} \right) = \frac{1}{(EP_1)^2} (-EP_1 + EP_2) > 0 \]  

(22)

Since (22) is positive, PROPOSITION 3 is proved.

**PROPOSITION 4**

The value of \( PEPI \) increases when the demand’s mean value decreases.

**PROPOSITION 5**

When \( (q_2 - q_1)(R-C+S) - (R-V+S) \int_0^{Q_i} F_0(y)dy > 0 \) and \( (R-C)\mu - K > 0 \), the value of \( PEPI \) increases when the demand’s standard deviation increases. The notation of \( q_1, q_2 \) and \( F_0(y) \) are defined in the following proof.

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Proof of PROPOSITION 4 and 5

$X$ is a random variable of demand with mean value $\mu$ and standard deviation $\sigma$. $f(x)$ and $F(x)$ are a probability density function and a cumulative distribution function of random variable $X$ respectively. Let $Y$ locate a point measured from the mean $\mu$ of a random variable $X$ with the distance expressed in units of standard deviation of the original random variable $X$ (i.e., $Y = \frac{X - \mu}{\sigma}$). The probability density function and cumulative distribution function of $Y$ are denoted as $f_0(y)$ and $F_0(y)$ respectively, where $f_0(y)$ and $F_0(y)$ are defined in the range from lower bound $a$ and $F_0(y) = \int_a^b f_0(y) dy$. $Q_1^*$ and $Q_2^*$ can be expressed as follows:

$$Q_1^* = \mu + \sigma F_0^{-1}\left(\frac{R - W_i + S}{R - V + S}\right) = \mu + \sigma q_1$$  \hfill (23)

and

$$Q_2^* = \mu + \sigma F_0^{-1}\left(\frac{R - C + S}{R - V + S}\right) = \mu + \sigma q_2$$  \hfill (24)

respectively. In (23) and (24), $q_1$ and $q_2$ are defined as $q_1 = F_0^{-1}\left(\frac{R - W_i + S}{R - V + S}\right)$ and $q_2 = F_0^{-1}\left(\frac{R - C + S}{R - V + S}\right)$ respectively.

$E_P$ can be expressed as

$$E_P = \int_{-\infty}^{\infty} \left(1 - F(x)\right)dx = \int_{-\infty}^{\infty} \left(1 - F(x)\right)dx$$

$$-\left[R - V + S \right] \int_{-\infty}^{\infty} F_0(y) dy + (\mu + \sigma q_1)(R - C + S) - K - \mu$$

$$= \sigma\left(R - V + S\right) \int_{-\infty}^{\infty} F_0(y) dy + (\mu + \alpha q_1)(R - C + S) + [(R - C)\mu - K]$$

$$= \alpha a + B, \quad a = 1, 2$$

where $A_i$ and $B$ are defined as

$$A_i = \left(R - V + S\right) \int_{-\infty}^{\infty} F_0(y) dy + (\mu + \alpha q_1)(R - C + S)$$

$$B = (R - C)\mu - K$$

Since $\frac{dE_P}{d\mu} = \frac{dQ_1^*}{d\mu}(R - C + S) - S = R - C$ from (23) and (24), one can derive

$$\frac{dE_P}{d\mu} = \frac{dQ_1^*}{d\mu}(R - C + S) - S = R - C$$

and

$$\frac{dE_P}{d\sigma} = -\left(R - V + S\right) \int_{-\infty}^{\infty} F_0(y) dy + (\mu + \alpha q_1)(R - C + S)$$

The preceding theory can be illustrated by the following numerical example where the parameters are given as follows: Probability density function of demand is uniform, $f(x) = U(m - r/2, m + r/2)$ with mean value $m=150$ and range $r=100$. Wholesale price paid by the buyer to the vendor, $W_i$=$80$ for scenario $i=1, 2$. Retail price, $R$=$100$ Unit shortage cost, $S$=$20$ per unit shortage Salvage value for each unsold unit, $V$=$10$. Vendor’s unit variable cost, $C$=$30$. Vendor’s fixed cost per setup, $F$=$1,000$. Negotiation factor, $\alpha=0.5$.

By applying the above theory, the results are given in Table 1-3. Table 1 illustrates the optimal solutions with various scenarios. For scenario 1 from the buyer’s viewpoint, the optimal order quantity is 136 units. The sales, unsold and shortage are 130, 7, 20 units respectively. The sales gross profit, unsold loses and shortage loses are $2,595, $463 and $405 respectively. The buyer’s, the vendor’s and the joint expected profits are $1,727, $5,828 and $7,545 respectively.

For scenario 2 from the collaborative vendor-buyer viewpoint, the optimal order quantity is 182 units. The sales, unsold and shortage are 148, 33 and 2 units respectively. The sales gross profit, unsold and shortage loses are $2,967, $2,343 and $33 units respectively. The joint expected profit increases greater. The percentage of expected profit increase ($PEPI_1$) is 15.07%. While the buyer expected profit decreases. The buyer will restrict joining in the collaborative system.

For scenario 3, the vendor may offer price discount to entice the buyer to collaborate. The order quantity is the same as that in scenario 2. When $\alpha=0.5$, the wholesale price is $69.6$. The wholesale discount rate is 13%. The vendor’s extra benefit is $379$, which is a half of the buyer’s extra benefit $758$. $E_P$ in scenario 3 is the same as $E_P$ in scenario 2.

The demand’s standard deviation is proportional to the range of uniform distribution (i.e., $\sigma = r / \sqrt{12}$). From Table 2, one can see that the value of $PEPI_1$ increases with respect to demand’s standard deviation. From Table 3, the value of $PEPI_2$ increases when demand’s mean value decreases. According to (28), since $(R - C)\mu - K = 9500 > 0$ and $(q_2 - q_1)(R - C + S) - (R - V + S) \int_{0}^{\infty} F_0 (y) dy = 39.4 > 0$ when $r=100$ and $\mu =150$, one can see that the value of $PEPI_1$ increases.

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when the demand’s mean value decreases or standard deviation increases.

4. Concluding remarks

An optimal replenishment and pricing policy is developed for uncertain demand. The numerical example demonstrates that the vendor-buyer collaboration results in an increase in the expected profit of about 15%. The negotiation factor is incorporated to balance the profit sharing between the vendor and the buyer. From the proposition, one can make the following conclusions: (i) the collaborative order quantity is larger than the non-collaborative order quantity (ii) the collaborative joint expected profit is greater than the non-collaborative joint expected profit (iii) the value of PEPI increases with respect to the vendor’s fixed cost and (iv) the advantage of considering collaboration is usually more significant when the demand’s mean value decreases and/or the standard deviation increases.

Table 1. Solutions with various scenarios

<table>
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<th>Terms</th>
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<th>After collaboration</th>
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<th>Diff. (2-2)</th>
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<td>182</td>
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<td>0</td>
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<tr>
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<td>80</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Sales</td>
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<td>18</td>
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<tr>
<td>Unsold</td>
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<td>33</td>
<td>26</td>
<td>26</td>
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<tr>
<td>Shortage</td>
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<td>-18</td>
</tr>
<tr>
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<tr>
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Table 2. Sensitivity analysis when the standard deviation of demand is changed

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<th>$\sigma$</th>
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<th>PEPI</th>
</tr>
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<td>250</td>
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Table 3. Sensitivity analysis when the mean of demand is changed

<table>
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<tr>
<th>$\mu$</th>
<th>Expected profit</th>
<th>PEPI</th>
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<td>After collaboration (II)</td>
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</table>

References


A PRELIMINARY FORECASTING WITH DIFFUSION MODELS:
TWITTER ADOPTION AND HASHTAGS DIFFUSION

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ABSTRACT

Twitter, a global social media, enriches the user’s experience of real-time information communication. Considering Twitter and its hashtag function as innovations, this study applies diffusion of innovation theory to gain understanding of Twitter adoption and hashtag diffusion. This study utilizes both automatic data collection from the Twitter API platform and secondary data collection to aggregate trend and adoption data. Two diffusion models, the Bass and logistic models, are chosen to perform forecasting growth patterns of Twitter adoption and hashtag diffusion. The preliminary forecasting results are productive though the models can be refined by taking into account more explanatory variables.

Keywords: Diffusion of innovations, Bass model, forecasting, microblogging, Twitter.

INTRODUCTION

Studying diffusion theory in the context of innovation is important because an innovation affects the life of individuals, communities, organizations, and countries, regardless of the form of innovation. Since the diffusion theory of innovation has been applied to various disciplines, including economics, marketing, sociology, and technology management, the notion of innovations can refer to new products, ideas, services, methods, or inventions. Innovation research requires typologies accounting for market and technology dimensions, which provide a structure to define innovation constructs and the applied domains [7]. These typologies imply that innovations are fundamentally different in various combinations of markets and technologies. Microblogging, a new type of information communication technology, allows users to publish and share short messages through multiple access points, such as mobile phones, Web, or instant messaging services. Therefore, diffusion theory appears to be germane for explaining the spread of new microblogging applications in the Web 2.0 environment.

Twitter, a popular global social media platform supporting by its microblogging service, enriches the user’s experience of real-time information communication without being tied to a single device. Twitter hashtags, a novel tagging convention by prefixing keywords with the symbol (#) and proposed and adopted by active users in 2007, serve as retrieval cues associating daily events with information resources. To get certain topics or hashtags show trends, users have to mobilize in a critical mass to include specific words or hashtags while diffusing the tweets. Like texture cues, the surfaced trending topics and hashtags reflect human interactions with the disseminated tweets. To make successful message diffusion possible, Dodd [4] suggested three chief factors: interactions among people (e.g., actors and reactors), acts (e.g., telling and hearing), and time. This study draws on the diffusion of innovation theories to explore the initial use of the Twitter service as an innovation adoption and user decision to continuously adopt Twitter. In addition, understanding the interaction between early adopters and follow-up adopters to diffuse trending topics provides a good case for analyzing continued use-behavior. As such, the first part of the exploration focuses on estimating the growth of Twitter adopters over five years; the second part emphasizes Twitter adopters’ continued use by investigating Twitter trend diffusion patterns.

THEORETICAL FRAMEWORK

Diffusion of Innovation Theory: Two Research Streams

Rogers, who developed the first model of diffusion, defined diffusion of innovation as: “the process by which an innovation is communicated through certain channels over time among the members of a social system.” [11]. For its adopter, an innovation could be any: “idea, practice, or object that is perceived as new by an individual or other unit of adoption.” [12]. The diffusion process consists of four key elements: innovation, the social system which the innovation affects, the communication channels of that social system, and time. [12]. One of the most influential theories of communication in marketing, diffusion theory focuses on the means by which information about an innovation is disseminated. Although Rogers’ model is classic and widely established, it has several limitations regarding its predictive power related to the dissemination of an innovation [1]. Therefore, Bass proposed his eponymous model to explain his discovery of how the number of adopters during a time period is almost identical to the number of sales throughout most of the diffusion process. This suggests that the number of adopters in a time period serves as a good proxy for sales. Thus, the Bass model has been revised and implemented in forecasting innovation diffusion in multiple fields. [9]. While the Bass model has potential to predict the distribution of the adoption curve, Rogers’ model serves as a comprehensive framework for understanding the diffusion process of an innovation and its underlying factors driving the diffusion.

DIFFUSION THEORY AND TWITTER ADOPTION

Despite the fact that Twitter has become a prevailing microblogging service as a global social media platform, there is currently a lack of diffusion research on microblogging or
Twitter applications. From a technology acceptance viewpoint, one study used the Unified Theory of Acceptance and Use of Technology (UTAUT) to model microblogging adoption within the enterprise [6]. Another recent and relevant study examined the impact of word-of-mouth on Twitter retweeting behavior employing content and social network analysis [14].

Twitter Adopters

When it comes to adopters of an innovation, Rogers assumes that the relationship between the number of adopters and time of adoption appears as a normal distribution. Rogers’ adopter category indicates that the innovators (top 2.5% of total adopters) and early adopters (top 16% of total adopters) play important roles in influencing potential customers in deciding to adopt the innovation. Without their influence, the diffusion process will not be able to continue. Moreover, the fast growing number of cumulative Twitter adopters confirms that users’ decisions to adopt Twitter rely on internal influences, i.e., interpersonal word-of-mouth or informal advertising, within the social structure instead of external influences (formal advertising or mass media). On the other hand, the Bass model emphasizes the two major categories of adopters, innovators and imitators, whose adoption are decisions driven by innovators’ influences.

Information Interaction in Twitter HashTags Diffusion

All the Twitter adopters are potential Twitter hashtag users. The list of Twitter daily top 30 trends demonstrates the competition between trends with hashtags and without hashtags, i.e., regular keywords. To get certain topics or hashtags to trend, Twitter adopters have to make efforts to mobilize a critical mass of adopters to include specific words or hashtags while diffusing the tweets. Like texture cues, the surfaced trending topics and hashtags reflect human interactions with the disseminated tweets. However, the conditions necessary for hashtag and non-hashtag diffusion to increase their use rates differ. While keywords diffuse as the (re)tweets contain the combinations of keywords, hashtag diffusion requires the inclusion of the hashtag symbol (#) in the (re)tweets. This study primary focuses on hashtag diffusion as hashtags serve as retrieval cues assisting in navigation and refindability.

Diffusion of innovation theory has established a solid theoretical foundation to study an innovation across disciplines; therefore, researchers can learn and benefit from what has been discovered in other disciplines. Through the lens of Diffusion of innovation theory and information interaction theory, it assists in evaluating hashtag life cycles and thus offering information required for decision-making, in regard to hashtag management [3].

FORECASTING TWITTER DIFFUSION PATTERNS: THE BASS MODEL

In order to study the phenomena of Twitter adoption and Twitter hashtag diffusion, different diffusion models can be used to analyze and predict diffusion patterns.

The Bass Model

Inspired by Rogers, Bass provided a mathematical theory for explaining the diffusion of an innovation. The Bass model assumes that adoptions or sales of an innovation are influenced by satisfied customers at a particular time. Early adopters who like the innovation spread the word and encourage potential customers to adopt it. Notably, the Bass Model has been examined in many industries and with many new technological innovations and services. There are two methods used to estimate the parameters of the Bass model from historical data: either finding analogous product estimates or using nonlinear regression. [13]. One study [8] in particular organized a list of the innovation (p) and imitation (q) parameters of the Bass model across more than 30 product/technology categories. Not only do microblogging services have yet to be tested using the Bass model but there seem to be no analogous products available. Hence, this study uses nonlinear regression to estimate the Bass model to forecast Twitter adoption. The variables for parameter estimation or for forecasting in the Bass models are composed of: the potential market (M), the coefficient of innovation (p), and coefficient of imitation (q). The Bass model has several forms of equation; here is the diffusion equation for estimating the Bass model using nonlinear regression:

\[ S(t) = a + bN_{t-1} + cN_{t-1}^2 \]

where

\( S(t): \) the number of adopters or sales in period \( t \)

\( N(t): \) the cumulative number of adopters up to time \( t \)

The values of \( a, b, c \) may be determined from ordinary least-squares regression. The formula of calculating \( p \) and \( q \) based on the values of \( a, b, c \) can then be obtained as follows:

\[ N = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \]

\( p: \) coefficient of innovation (coefficient of external influence) \[ p = \frac{a}{N} \]

\( q: \) coefficient of imitation (coefficient of internal influence) \[ q = p + b \]

\( N > 0, b \geq 0, \) and \( c < 0. \)

Applying the Bass Model to Twitter Diffusion

Data Source

Twitter adoption data were collected from the company data website, Infochimp.org. This dataset counts the number of users who created accounts and sorts them by year, month, and day between March 2006 and March 2010. Because the
monthly dataset has no missing data, this study uses it as the chief data source for estimating the Bass model for Twitter adoption. In total, the number of past periods (between March 2006 and February 2010) for fitting the Bass model estimation is 47 months after removing the outlier (March 2010).

The Bass model assumes that \( M \) is constant; however, it often changes in practice. Two approaches to estimating potential market [2]: either a fixed constant or a function that changes over time with the decision variables. This study assumes a constant due to the short term time series data (47 months). Combining the data from Infochimp.org (March 2006–February 2010) and the Twitter announced statistics in March 2011, we plotted the cumulative number of Twitter adoptions (Figure 1) by year since Twitter’s introduction in March 2006.

![Cumulative Adopters by Year](image1.png)

**Figure 1** Twitter Cumulative Adoptions: 5 Years since Introduction

Source: This study.

Generally, this study found that the number of adopters over five years has grown significantly. However, as shown in Table 1, the growth rate has become more stable within these two years.

**Table 1** Twitter Adoption Growth Rate

<table>
<thead>
<tr>
<th>Year</th>
<th>Cum. Adopters</th>
<th>Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>69941</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>884317</td>
<td>1164%</td>
</tr>
<tr>
<td>3</td>
<td>10183187</td>
<td>1052%</td>
</tr>
<tr>
<td>4</td>
<td>42715285</td>
<td>319%</td>
</tr>
<tr>
<td>5</td>
<td>200000000</td>
<td>368%</td>
</tr>
</tbody>
</table>

Source: This study.

Therefore, in order to determine the maximum market potential (\( M \)), this study projects the potential Twitter adopters to be 700 million for the following year based on the assumed growth rate of approximately 350%.

### Estimating parameters of the Bass Model

The Bass model is characterized by describing the interaction between innovators and imitators. It is also called a model of social contagion where \( p \) (the innovator coefficient) denotes the probability of initial adoption independent of others’ decisions to adopt the new product or service; \( q \) (the imitator coefficient) measures the social contagion effect (like word-of-mouth) on adoption. The results of the estimated nonlinear regression using Stata 11 are displayed in Figure 2. The coefficients (\( b \) and \( c \)) on both cumulative adopters lagged one month (\( laadopters \)) and the square of cumulative adopters lagged one month (\( sqladopters \)) are statistically significant at 5% in terms of predicting the cumulative adopters in period \( t \).

![Figure 2 Output of the Estimated Nonlinear Regression](image2.png)

**Figure 2** Output of the Estimated Nonlinear Regression

Source: This study.

The values of the Bass model parameters are then calculated using Stata 11 as follows (Figure 3):

![Figure 3 Output of the Estimated Parameters for The Bass Model](image3.png)

**Figure 3** Output of the Estimated Parameters for The Bass Model

Source: This study.

The estimated parameters reveal that the innovation effect (\( p \)) = .00002, is not statistically significant (p value = .557 > .05) in predicting cumulative Twitter adoption while the imitation effect (\( q \)), 1.4073, is statistically significant (p value = .000 < .05) in predicting cumulative Twitter adoption. The small innovation effect indicates that the intrinsic tendency for a user to adopt Twitter is insignificant, whereas the high imitation effect shows that significant social contagion effect drives an acceleration of Twitter adoption. It is worth noting that when the \( q \) value is equal to 1, it means that non-adopters will adopt Twitter for certain once they hear about it from a previous adopter [8].

### Forecasting analysis using the Bass model

The historical time series data (from March 2006 to February 2010) was used to generate the model. Although the recent one year adoption data is not available, the most recent adoption data Twitter announced is used to compare the inflection point. As a result, the estimated Bass forecasting model is consistent with the recent Twitter adoption data (approximate 200 million adopters as of March 21, 2011). However, when maximum market potential (\( M \)) is assumed to reach 700 million adopters, the forecasting inflection point was reached (in the end of 2009) about one year earlier than the actual data. As the market potential changes, the inflection point approaching the saturation level also changes. Even so, the model with \( M = 700 \) million fits better than those with lower or higher \( M \) values. Since this preliminary study estimated the basic Bass model, there is still room for
improvement. The forecasts for different scenarios or extending the basic Bass model by including significant decision variables might help reduce the bias and further improve the forecasting accuracy.

![The Bass Model](image)

**Figure 4 Twitter Diffusion Pattern Estimated by the Bass Model**

Source: This study.

The observed diffusion pattern from the Figure 4 presents the S curve indicating the imitation effect dominating the innovation effect. In pursuit of model optimization, some extensions of the standard Bass model have been proposed to account for repeat purchases (uses) of a product (an innovation), allowing varying market potential (M), examining the effects of incorporating marketing variables over time, and so forth.

**PREDICTING TWITTER HASHTAG DIFFUSION PATTERNS: LOGISTIC GROWTH MODEL**

As the historical data for hashtag initial use is unavailable, the logistics curve is considered a more appropriate model.

**Simple Logistic Growth Model**

The logistic growth equation is one of the most widely applied models for technology forecasting. This model features its symmetric inflection point, the time at which the number of adopters stops accelerating upward and starts reaching the saturation level. This model helps investigate the pattern of a technology’s life cycle from slow growth, rapid growth, and decreasing growth to decline.

The logistic equation is express as

\[ Y_t = \frac{L}{1 + ae^{-bt}} \]

where

- \( Y_t \) is the market share (or adoption rate)
- \( L \) refers to the saturation level, and \( a \) and \( b \) describe the curve

**Applying Simple Logistic Growth Model to Twitter Hashtag Diffusion**

**Data Source**

Many leading Web 2.0 companies release application programming interfaces (APIs) to encourage the use of their data and services in the development of new applications. As such, utilizing APIs has become a method for collecting Web system actual use data. Twitter makes public its API enabling developers or researchers in order to encourage the use of programming languages to enhance existing functions or communicate with the Web servers in order to fetch data. Thus, this study uses Twitter API to assist in Twitter trend data acquisition.

To better quantify Twitter hashtag usage, this research will deploy an automated data collection method through the writing of a self-designed program with Java and MySQL database to directly retrieve data via the Twitter API. For example, weekly trends return the top 30 trending topics for each day in a given week. In the database, the three primary tables containing trends, country, and city, were created to gather data.

Like keywords, the hashtags that are being most widely used will be displayed as the top ten trending topics. Ideally, instead of keywords, hashtags should be promoted as cues or indices to efficiently organize and share Twitter messages. Based on a recent three-month observation of Twitter, 2–3 out of the daily top 10 worldwide trending topics contain hashtags. However, the distributions may be uneven across different countries. Accordingly, the diffusion theory of innovation can help examine whether hashtag use activity varies as it is disseminated during different time periods and across cities or countries. This preliminary study starts with the logistic diffusion model focusing on the hashtag growth rate during certain time periods. The comparative analysis of hashtag growth rates across cities and countries will be conducted in the next research stage.

**Estimating Logistic Growth Model**

As summarized in Table 2, this study retrieved 5522 trends from April 2010 to December 2010 as the sample for examining hashtag diffusion.

![Table 2](image)

Source: This study.

While 40% of trends have occurred more than once, 60% of trends are distinct trends appearing one time. It implies that Twitter adopters have routinely reused or recycled hashtags in order to exchange tweets. In both distinct and repeated trend categories, hashtag rates are 26.64% and 28.67%, respectively. The hashtags rate is a little higher in the repeated trends than the distinct one.

Estimating logistic growth with an unknown saturation level is very difficult. To resolve this issue, we utilize the Twitter API to retrieve the daily top 30 trend (with or without hashtags)
data to examine hashtag growth patterns. Therefore, in the case of Twitter top hashtag use, the saturation level is known. Since the data collected for estimating the logistic model consists of the daily Twitter top 30 trends, we can easily obtain the market share of hashtags (meaning the percentage of hashtags takes over the top 30 trends) and assume that the saturation point is 1. We aggregated the daily hashtag rate data (between 2010/4/11 and 2010/12/31, total sample size is 231 cases) to monthly hashtag rate data by calculating the average hashtag rate for each given month.

**Forecasting Analysis Using the Logistic Model**

The logistic curve can also be used to estimate the growth rate for the following terms. As displayed in Table 3, the monthly hashtag rate (market share) and the least-squares fit to the logistic function are used to predict the values of projected hashtag rates. The forecast provided by the logistic equation shows hashtag rate ranging from .25 to .39, with an average around .0308. To ensure the accuracy of the forecast, we have observed and recorded the hashtag rate in daily top 10 trends since Jan. 1st, 2011. The pattern is consistent with the hashtag rate, in the range .20 to .30, with an average equal to .25.

**Table 3 Forecasting Analysis of Hashtag Rates**

<table>
<thead>
<tr>
<th>Year/Month</th>
<th>Hashtag Rate</th>
<th>Regression fit of exponential growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010-Apr.</td>
<td>0.09</td>
<td>0.0838</td>
</tr>
<tr>
<td>2010-May.</td>
<td>0.25</td>
<td>0.0969</td>
</tr>
<tr>
<td>2010-Jun.</td>
<td>0.20</td>
<td>0.1120</td>
</tr>
<tr>
<td>2010-Jul.</td>
<td>0.17</td>
<td>0.1294</td>
</tr>
<tr>
<td>2010-Aug.</td>
<td>0.21</td>
<td>0.1496</td>
</tr>
<tr>
<td>2010-Sep.</td>
<td>0.25</td>
<td>0.1729</td>
</tr>
<tr>
<td>2010-Oct.</td>
<td>0.34</td>
<td>0.1998</td>
</tr>
<tr>
<td>2010-Nov.</td>
<td>0.29</td>
<td>0.2309</td>
</tr>
<tr>
<td>2010-Dec.</td>
<td>0.30</td>
<td>0.2669</td>
</tr>
<tr>
<td>Forecast</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extrapolation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011-Jan.</td>
<td>0.24</td>
<td>0.3084</td>
</tr>
<tr>
<td>2011-Feb.</td>
<td>0.26</td>
<td>0.3564</td>
</tr>
<tr>
<td>2011-Mar.</td>
<td>0.29</td>
<td>0.4119</td>
</tr>
<tr>
<td>2011-Apr.</td>
<td>0.32</td>
<td>0.4761</td>
</tr>
<tr>
<td>2011-May</td>
<td>0.35</td>
<td>0.5502</td>
</tr>
<tr>
<td>2011-Jun.</td>
<td>0.39</td>
<td>0.6359</td>
</tr>
</tbody>
</table>

Source: This study.

By fitting a logistic curve to the 9-month hashtag use data (from April 2010 to December 2010), we are presented with the stable growth of hashtag use because the rapid growth of Twitter adoption occurred during the time periods. As more adopters use hashtags, they influence other adopters to adopt and diffuse the hashtags. It indicates that there might be a network effect assisting the hashtag diffusion.

**Implications**

Viewing Twitter as an innovation, we applied the basic Bass model to understand the interactions between innovators and imitators and the impacts on their decisions to adopt the innovation. Surprisingly, our findings show that Twitter early adopters, i.e., innovators, were not significantly affected by external communication effects attributed to advertising campaigns. However, the imitation effect coming from interpersonal word-of-mouth communication has a significant impact on Twitter adoption. The faster growth rate of adoption might associate with the characteristics of Twitter, such as perceived relative advantage of adoption, compatibility with existing user experience, observed benefits, and so forth. Additionally, based on the logistic growth model, Twitter hashtags diffusion would be likely to progress in the same manner as Twitter adoption. The more people that are talking about a hashtag, the more people in the social system will adopt its use.

**CONCLUSIONS**

The Bass model helped postulate that the Twitter adoption and diffusion rely on word-of-mouth communication process between innovators (i.e. early adopters) and imitators. The Twitter adoption and diffusion process was modeled and represented as an S-shaped trend curve illustrating the life cycle of Twitter growth. With historical observations, the Twitter diffusion modeling also assisted in predicting time period to reach maturity.

The prelude of diffusion modeling characterized the process of Twitter adoption and diffusion: in terms of consumer adoption decisions, Twitter early adopters, namely innovators, were not significantly affected by external communication effects attributed to company advertising or marketing strategies. However, the innovators generated significant imitation effects through interpersonal word-of-mouth communication to motivate the adoptive behavior of potential customers. In addition, the rapid growth rate of Twitter adoption and diffusion patterns might associate with the Twitter characteristics, such as perceived relative advantage of easy adoption, compatibility with existing user experience, observed benefits of real-time information sources, etc.

Moreover, similar to the original Bass model, there are other diffusion models facilitating explanations of various diffusion paths according to different assumptions, data requirements, or refinements of the Bass model. Meade & Islam [10] succinctly summarized the widely accepted diffusion models applicable to forecasting the diffusion of innovations and suggested several principles pertinent to model selections, prediction intervals, and uncertainties.

Likewise, based on the logistic growth model, Twitter hashtag diffusion would be likely to progress in the same manner as Twitter adoption. The imitation effect from word-of-mouth communication on the hashtag diffusion was significant. Hashtag diffusion acted both directly on hashtag adoption and indirectly as interactive communication occurred to promote hashtag awareness. In other words, the more Twitter adopters
that are talking about a hashtag, the more adopters in the social system will consider its use. The power of social contagion explains the rapid increase in Twitter adoption over five years and allows Twitter hashtag diffusion to quickly define trends.

**FUTURE RESEARCH DIRECTION**

IS/IT adoption and diffusion research in the Web2.0 context is still in the infancy stage and warrants further investigation. Further research is necessary to explore applicable theories, predictors, linkages between variables, and new methods to share the accomplishments and bridge the gaps across domains. Much more needs to be known about the way people locate, exchange, and preserve real-time web content they find useful and relevant in the Web 2.0 environment.

The diffusion models (i.e. the basic Bass model and the simple logistic curve model) in the first empirical data analysis provide an exciting first step to determine the contagious interaction between innovators and imitators to diffuse the trends. However, future research is obviously required to further investigate the social interaction of “telling-and-hearing a message” [4] over time across locations. To make tweet diffusion predictable, an important area for future research will be in the refinement of approaches to the analysis of various diffusion models, in particular measuring the correlation of innovator (i.e. actor of a hashtag) and imitator (i.e. reactor of a hashtag) effort to communicate.

Diffusion modeling [5] studies are concerned with observed patterns in which innovations appear at growing speed and diffusing in scope as they spread across potential adopters over time. The observed differences between low innovation and high imitation effects on Twitter adoption and hashtag diffusion led us to the question of the significant impacts of social interaction or mobilization. Several experimental studies controlling for trend category or temporal intervals could be undertaken to determine different use case scenarios of social interactions. The potential of the meaningful use of such social interaction during the time-based events clearly needs further exploration by diffusion modeling.

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Apple Technology Aesthetics: Apple’s Era, Apple’s Way
Lessons learned for Taiwan’s Service-Economy-Oriented Growth

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ABSTRACT
Taiwan has always been a center of OEM manufacturing of computers and peripherals. The importance of contribution from Taiwanese firms cannot be overemphasized. People in Taiwan humored the fact with: Who said OEM is not a good task?!

One of the shining achievements was done by Foxconn, which magnified Apple’s market shares across full product spectrum. Overall, apple’s overall market share has increased from 5 percent to 25 percent; and is on its way to an expected 41%. Foxconn had created the sixth forces, known as the complementor, in Michael Porter’s Five For...
One of the shining achievements was done by Foxconn, which magnified Apple’s market shares across full product spectrum. Overall, apple’s overall market share has increased from 5 percent to 25 percent; and is on its way to an expected 41%. Foxconn had created the sixth forces, known as the complementor, in Michael Porter’s Five Forces framework for Apple. The partnership between Apple and Foxconn had evolved beyond the so-called Brand and OEM relationship. And en route this evolution, the scarcity of value had progressed to the fair-price indulgence of luxury goods. Apple actually has preserved the capacity to create the expected prospect of low-price indulgence of luxury goods. But as a for-profit business, Apple has chosen not to do it.

The Value Net of Apple Computer

Before encountering Foxconn, Apple never thought of turning big in market share. There may have been a whim, but Apple’s then CEO was from a beverage giant company and was most familiar with commodity marketing and selling. The commodity marketing mindset and then immature global sourcing (at the inception stage of supply chain) had created a bulk quantity of all kind of configurations with varying component quality and overall integrity. A lot of remanufactured Apple products went into auctions as a result. The Apply crowd was not spirited. Then we saw the legend coming back of Steve Jobs. His landmark style brought Apple back to elegant product line. Each product in the line is featured by excellent technology that amazes users.

Under the leadership of Steve Jobs, the products under Apply umbrella are featured by aesthetics; and equally importantly, the technology superiority. The product line is short but complete with diamonds-like. The OEM role played by Foxconn is featured by superior capacity: fastest speed, lowest cost, and most stringent quality assurance. Foxconn had helped Apple create the monopoly market of technology aesthetics. The only potential and possible competitor of Apple is probably Sony, another technology giant. The matching strategies of Apple include: devising affordable pricing, embracing the Microsoft Windows system. Altogether, the grand strategy had grounded solid foundation for Apple’s dominating presence.

The co-evolution of Apple and precision OEM manufacturer Foxconn reminded us the legend Fuji Apple species in Switzerland, which is rich in antioxidant content and may help keep people healthful and young. With Taiwan’s superior agriculture technology, the close-to-extinct precious species can be saved and can multiply to benefit millions of potential consumers. Such aesthetics stories are not isolated incidences; they are creating the new landscape of businesses with their complementors. Assuming that Mercedes or BMW encounters its complementor to magnify the throughput exactly and affordably, will there still any room for mediocre cars? Aesthetics echoes the phenomenon coined by Schumpeter: Creative destruction. Creative destruction is powered by amazing forces which pave the roads for superior innovation by sweeping into ashes the obsolete and inferior products.

APPLE’S SNOWBALL EFFECTS

The bigger grows even bigger phenomenon usually exists only in merchandise of digital content. However, it has also realized in Apple aesthetics. We also discovered such realization in other key technology aesthetics: Dyson on vacuum cleaners and bladeless fans, Mercedes on sports cars, Studio Classroom on English-learning as the second language. Each of the aforementioned technology aesthetics giants share a common feature: deep technology pocket. As organization theorist James March vividly said: Such technology dominating players possess a current garbage can (a diamond case in disguise for tomorrow) with answers and breakthrough know-how to tomorrow’s demand-driven innovations. Only those companies striving for excellence on a day-to-day diligence will be ready to cherry-pick the markets when the door of opportunities suddenly unfold.

Apple has demonstrated superior prudence providing products and services: intelligent Internet interface, uploading and downloading services, interfaces and infrastructure for software creators. Apple has facilitated the creation of markets and cash flows for software coders and for Apple herself. The technology superiority, clouds-computing applications creation and facilitation, and the linkage and integrated development among such, had pushed Apple to the commanding height leadership on technology aesthetics. No wonder we say: Apple’s era, Apple’s way.

The emergence of Apple series drew a clear line with other commodities. To certain extent, Apple had weakened other delicate products to ordinary yet pricey commodities. What had caused the decline in PC sales may well have been caused by PC becoming furniture or commodity. After all, not all families need to replace furniture yearly. Nowadays when customers busy shopping PCs they feel amazed by manufacturers’ churning and flooding of products of similar specifications without genuine technology aesthetics. Another obstacle for advancing PC sales may also have been triggered by people asking themselves: Why do I want another PC? Shouldn’t I get an iPad instead? This is indeed a million dollar question.

Apple’s iPad is ideal for all users, old and young; and for all

The 11th International DSI and the 16th APDSI Joint Meeting, Taipei, Taiwan, July 12 – 16, 2011, pp.513-519
purposes, recreational and professional/serious. iPad helps software engineers create and learners learn. The unbeatable advantages of iPad arise from its creation of the sustainable snowballs. Each snowball expands when the critical mass enjoys the iPad and iPhone, and escorts the market merits and growth of Apple, along all product lines. Each snowball of Apple’s has full potential becoming a niche market wave-front—once exploited it will transform the snow into Haagen Dazs or Moven Pick to capture more frontier and advanced opportunities. Apple’s rich snow ball effects include:

Snow Ball Effect One

The joining of digital content participants. Famous publishers including Economist Magazine, Harper Collins Business Series, McGraw-Hills College Textbooks Publishing, Studio Classroom were all suspicious about digitalizing their authoritative content time ago; but have all chosen to work with the leading brand Apple to test the market. The reason is obvious, the amazing power of Internet may magnify any smaller but good player in digital content providing business to surpass the incumbent leader. Not too long ago Apple acquired a popular music subscribing services provider LuLu; and it expressed Apple’s determination of continuing to be the leader in Internet platforms of uploading new creation in music and of downloading music.

Snow Ball Effect Two

Snow Ball Effect Two: Apple’s market creation power and platform providing have created a wonderful meeting place for digital content lovers and creators, known as the primary market for creative enterprises. The cradle for tomorrow’s stars has helped many to chase and realize their dreams at most affordable price and with satisfactory efficiency.

Snow Ball Effect Three

Snow Ball Effect Three: Emerging market Apple fans have joined the Apple crowd at amazing speed for the Apple aesthetics and the “I”-ego. It’s not the usual passing fad; it has embraced the disparity of hardware vs. software acquiring costs, seen often in emerging market. Such disparity created the psychology of iPad being amazingly great and affordable. We can foresee that in the near future, when US college E-textbooks become prevalent in Asia, even more netbook users will jump ship to join iPad group to enjoy the greatest pleasure of reading and learning. Converters will soon find that iPad will help embark on knowledge management and time management; and iPad will act as an indispensible helper and housekeeper in the era of knowledge economy.

Snow Ball Effect Four

Snow Ball Effect Four: Beneath the shining surface and glory of Apple, lies constant cultivation and long-term effort. Apple has reached out student population for long time by providing huge discounts and financing services to students and faculty at colleges in United States. Apple knows that college students are the most sophisticated users (of her innovative gadgets) among all; and college kids will provide the immediate feedback for product improvements. Apple can perfect her products with the enthusiastic feedback from the advanced users; and Apple benefits the most. The computer user club or group in colleges gathers snow and momentum, and over time forms a snowball of ever-increasing size and a host of niche opportunities (e.g., in forming elite social networks). When the smart kids promote the Apple gadgets to friends and families, they become the most enthusiastic volunteer teachers and help boost and retain the user population.

How affordable is the price of Apple iPad to U.S. college students? It’s not even a sweet burden—just sweet and no burden. On average, an U.S. college textbook costs US$200; and an iPad costs three times of that. However among its many functions, iPad can be used as a highly capable carrier of e-Textbook which is priced at one-third of the price of a hardbound copy. Therefore, savings from swapping printed textbooks with e-Textbooks for four courses will pay for a long-lasting iPad. Beyond the e-Texts, learners may also have access to magnificent collection of e-Magazines and e-content in US college libraries. Acquiring an iPad is much like obtaining a fishing rod and receiving free fishes at the same time. No wonder that we see every students having one iPad on campuses; and it’s not to our surprise that when the lady lost her bag, she worried most about her iPad in the lost bag.

Not just iPad, iPhone also possesses the merits of saving money for users. For such reason, it pays off quickly on Apple users’ investments in gadgets. Remember what we learn from finance: “A penny saved is a penny earned.” If you ask a free lance writer or software coder about Apple’s power of helping users save, you will receive an immediate and definite answer. Didn’t we see the free lance software coder concentrated on his/her creation at Starbucks, with the standard and parsimonious equipment set: a cup of coffee, an iPad, and an iPhone.

When the overwhelming portion of our spending sprees on reading and recreational audio-video enjoyments flows like water into a reservoir, water-level or business opportunities arise. Digitalization had accelerated the injection into the reservoir; and reservoirs formed and attended by digital content creators, Internet and phone services providers, among others, are all centered about the super-sized reservoir: Apple.

The seemingly insignificantly cash flows generated from Apple’s services charges on content providing and Internet and communications services facilitating is long-lasting and stably increasing. The cash flow decreased Apple’s dependence on the revenue streams generated from selling the hardware gadgets, which in turn provide Apple with the margin and capacity to lower the price to help realize the desire of indulging the fairly-priced luxury and even the dream of indulging the easily affordable luxury.
Apple aesthetics and technology superiority granted Apple with the power of pricing; and better still, passing through the surplus to the contributors in or along the value chain and supply chain according to the significance of the contribution. For example, Morris Chang at TSMC proudly claimed: TSMC receives 7 US Dollars for each unit of iPhone manufactured. The pricing power allows Apple to enjoy a fat margin and the power to price strategically. The overwhelming crowd provides the efficient amortization of the fixed cost to sustain Apple's intensity, dedication and momentum on research and development.

Technology and aesthetics giant Sony is a rare competitor of Apple, having equally profound technology base across far many more domains. Apple has been talking to Sony regarding sourcing its camera lens technology (Sony’s Alpha series are featured by the shake-resistant proprietary technology) to further perfect iPad and iPhone. It’s foreseeable that iPad3, iPhone5 and the series on the road will be even better than what we could expect. No wonder the forward-looking financial analysts are modifying up Apple’s financial forecasts to reflect the ever better prospect. Actually Apple’s heyday is yet to come and the real success and dominating market share will be achieved when Apple maneuvers pricing schemes to unfold to general public the possibility of indulging easily affordable technology aesthetics. If Apple chooses to do so, then Apple’s market share will be as high as Apple ever wants it to be. But we know that Apple will not engage in such a strategy any time soon or ever. Instead Apple will just shorten time to market from the research hub to maintain the technology and aesthetics leadership, with lucrative margins. Apple’s objective has always been striving for excellence. Competitors may create their competitive edge via health and environmental merits of reduced electromagnetism waves, or via acquiring exclusive privileges over rights showing over Internet the Royal Palace collections in Taipei and temple cultural aesthetics in Tainan, or via the convenient and free access to Chinese cultural treasure (burned into the gadget’s ROM), or via creating a critical mass from populations of Chinese origins in Taiwan, Hong Kong, Singapore and China.

When Technology Superiority Encounters Monetary Policy Initiatives
Apple caught the perfect timing of quantitative easing (or the weakening of US Dollar) in the States and accelerated her domination role on technology aesthetics to the blue sea. Foxconn also strived to capture the timing and advanced advantage of tariff free (to the Americas) via free trade agreement by storing up capacity in Brazil. That is, when Apple is opening up markets globally while US Dollar is weakening, Foxconn also is also working on deepening costing down effort via tariff reducing and manufacturing at (or near to) where the markets are to enhance savings from economy of scale.

That’s why Foxconn has been acclaimed as the super OEM manufacturer! Beyond the track record of superior manufacturing capability and capacity on handling large and sudden orders, Foxconn has repeatedly demonstrated visionary judgment on grasping timing and advantage over trade treaty. Foxconn has therefore been acclaimed as the legendary partner of Apple.

In general, when local currency depreciates, or when competitor’s chain breaks due to disasters, it’s time to broaden the incumbent’s business landscape and market share. For example, after the bursting of European financial crisis, Euro adjusted downward and the imports of Mercedes and BMW to Japan, the luxury Japanese cars faced the broken chain and once again have to recede in market shares in global markets to Mercedez and BMWs.

During the recovery from the recession in the United States, Intel and Apple, among other highly innovative corporate America had protected the technology core and technology advances of US economy from deteriorating. Apple’s technology and aesthetics further proved that technology originates from the objectives of serving human needs and creating inspiration for better life. Technology with aesthetics may create, increase and sustain social surpluses. Apple fulfilled our wildest expectation in fulfilling such a goal; and created the trend of facilitating the majority’s indulging superior technology aesthetics within their means. Apple not only helped sustained US economy, but also benefited customers and investors alike. In addition, Apple had helped boost US GDP! What a great achievement have you made, Apple!

WHAT CAN TAIWAN LEARN FROM APPLE’S TECHNOLOGY AESTHETICS AND SUCCESS?
Taiwan may learn to develop his service-economy-enhanced plan from the Apple experience. We notice that Apple tried to be the best it can be, before ever thinking of turning big. There is a great wisdom and philosophy supporting this strategy. This is a portable concept in

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service-economy-enhanced endeavors. Let’s illustrate this with Yale’s Asian Campus Initiatives in Singapore. Since Yale had taken the cream of the crops in the States, Yale hopes to also take the best and the most representative young scholars in the fast-growing Asia, Yale set a quota of 1,000 intake in her proposed Asian campus in Singapore. It’s a small, quality-dominating, yet influential program for Asian elites and future leaders. When the program has achieved record success, it may expand. Without the complementor or the magnifying glass, the Yale in Asia program better be small since small is beautiful at the inception! That’s the essence in Apple’s technology and aesthetics at the inception.

LESSONS LEARNED FOR TAIWAN’S SERVICE-ECONOMY-ORIENTED GROWTH

Example One for Taiwan

Let’s think of another example in Taiwan. ROC government is proposing to start English education as a second language early in elementary school. We strongly support it and we know that since it’s about Taiwan’s infrastructure enrichment and soft power development, we have to start the early English education initiatives in grand scale so as to harvest with the highest throughput. However, when we think about the English-Taught Degree Programs in colleges, we have to think about Apple’s aesthetics philosophy, i.e., “small is beautiful” at the inception stage. Due to the desired high quality on exchange and local English-taught programs, we have to create partnership or alliances among universities within a nearby cluster of universities. Each program hosts the best available faculty for the highest teaching quality on their cups of tea. Then promote cooperation within cluster and across clusters to magnify without incurring extra costs. We have to use the established infrastructure advantages in Taiwan (e.g., the high speed bullet train may connect the south and north in Taiwan in just 1 hour and 36 minutes) to allow small and beautiful programs to exchange, to cross-support, and to magnify. We can make sure that the money is well spent and the achieved results are excellent and sustainable.

Example Two for Taiwan

Another important initiative from ROC Government is to enhance the overall English capabilities of the career professionals. Again it is a key infrastructure development project and demands grand-scale effort and harvesting alike since time being a key strategic dimension. Here the “small is beautiful at the inception” is realized by taking what you need from the complete spectrum (in terms of difficulty) of the highest quality. Such a spectrum is available in Taiwan in the premier series of Studio Classroom (Basic, Intermediate, and Advanced) and available in the States from McGraw-Hill English Learners’ Series. The Studio Classroom series is also available via Internet, broadcasting, e-Text, and iPad-catered edition. The beauty of cherry-pick-in-a-complete-spectrum resides in its flexibility as à la carte or buffet meal, contingent upon the reader’s appetite or capacity. After the study and test period, learners will enter the long-stay stage in an all-English environment to create the needed seasoning and critical experience; and the momentum of continued study.

Example Three for Taiwan

Taiwan is developing her service-industry-oriented economic plan, among other vivid engagements and efforts. The author noticed in his recent trips to the Hsin-Yi District in Taipei that whether it is about progress made on infrastructure enrichment, on the atmosphere of city buzz and sense of prosperity created, or on the fashion and stylishness of dressing nurtured, the business district in Taipei is on par with the ones in major Asian cities. The key question is: How may we best replicate and multiply the success to the key cities in Taipei and in Taiwan, and then again to the second-tier cities? In addition, the author found though, Taipei may host more boutique stores at varying and complementary price ranges. The best way is to joint-venture with some key US Outlet Malls (e.g., Nordstrom Racks, Marshalls, T.J. Marx) to have exhibitions and sales in Taipei exhibition centers near the Taipei World Trade Center during the non-peak seasons in the States. It’s also possible to work with CostCo (Price Club) to create increased selection on key brands (e.g., Polo Ralph Lauren) in a wide price and selection spectrum to create pleasant choices across all income levels.

Contrasting Apple’s Success with Volvo’s Dilemma

A company excels in technology and aesthetics may still face difficulties in flourishing or stay sustainable. One such example is Volvo Cars, a privately-held company excels in R&D and product integrity. The failure of creating profits or staying afloat has caused Volvo to be sold twice, at a significantly lower price at the second time. It remains doubtful regarding Volvo Cars’ sustainability and its long-term fate. We contrast Apple’s and Volvo’s strategies in Table 1—the essential one being Apple is for profit while Volvo has multiple objectives and questionably strikes between for profit and not-for-profit enterprises.

Volvo is similar to Apple in terms of having a deep technology pocket, emphasizing R&D and enjoying great accumulated results (e.g., patents, technology know-how), paying full attention to product aesthetics, details, integrity, and product integrity. Volvo’s product line is just like that of Apple’s: elegant yet adequate. The patronage of loyal drivers of Volvo is also not seconded by that of Apple’s.

However, Volvo falls way behind of Apple in term of agility of sourcing globally and producing and assembling globally at (or near) where the markets are. Volvo preserves most job opportunities in Sweden (under his strong union and by revealed corporate objectives) and to maintain the highest quality. By so doing Volvo incurred a high factors price at overly strong Sweden SKR and failed to increase price in the major market (i.e., US) due to the severe price competition. Volvo’s time to market from laboratory is relatively slow—an example being the commercialization of the C30 hybrid: three more years to go to mass produce after the prototype had been released. When Volvo lost money in 2008 and beyond, the company had to cut the payroll and layoff most significantly, let alone preserving enough number of jobs in Sweden. We do believe that Volvo Cars should adopt an objective of maximizing the surplus; so that it may preserve the values that the company cherishes.
Table: Apple vs. Volvo on Sustainability

<table>
<thead>
<tr>
<th>Objective</th>
<th>Apple</th>
<th>Volvo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profit Optimization</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>R&amp;D &amp; Preserving Employment in Sweden</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Cash Flow</td>
<td>Healthy, lots of Free Cash</td>
<td>In Red Ink</td>
</tr>
<tr>
<td>Accounts Receivables A/B/C &amp; D</td>
<td>Securitize Accounts Receivables A/B/C &amp; D</td>
<td>Securitize Accounts Receivables A/B/C &amp; D</td>
</tr>
<tr>
<td>Labor</td>
<td>14,000 in US</td>
<td>9,545 in US</td>
</tr>
<tr>
<td>Union demands local hiring</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Currency</td>
<td>USD</td>
<td>Sweedish SKR</td>
</tr>
<tr>
<td>Weakening</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Capacity Usage</td>
<td>Overcapacitated</td>
<td>Underutilized</td>
</tr>
<tr>
<td>Time to Market</td>
<td>Market Viable</td>
<td>Slow</td>
</tr>
<tr>
<td>Economy of Scale</td>
<td>YES</td>
<td>Some models losing money</td>
</tr>
<tr>
<td>Economy of Scope</td>
<td>YES</td>
<td>Some models losing money</td>
</tr>
<tr>
<td>SUSTAINABILITY</td>
<td>YES</td>
<td>Depends</td>
</tr>
</tbody>
</table>

Table: Apple vs. Volvo on Sustainability

Competitiveness is Real Exchange Rate (“<1”) for mature technology under shining brand names

<table>
<thead>
<tr>
<th>Volvo</th>
<th>BMW</th>
</tr>
</thead>
<tbody>
<tr>
<td>If in US, the price of BMW is higher than that of Volvo, then BMW is less competitive than Volvo. Hence price is about equal for luxury cars. The combat is on costing down! And BMW assembly the above S.U.'s in United States.</td>
<td></td>
</tr>
</tbody>
</table>

Table: Sheer competition among luxury cars in the US markets.

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ABSTRACT

In this study, we tried to find out the relationship among repatriation assistance, work satisfaction of repatriates, and life satisfaction of their family members. 180 questionnaires were sent out via friends, directly or indirectly, to repatriates and their spouses in a Taiwan’s public institute. With a response rate of 58.33%, 105 returned questionnaires were completed and usable. Applying multiple regression models, we found out that work satisfaction positively and significantly affected family members’ life satisfaction; repatriation assistance positively and significantly affected work satisfaction and family members’ life satisfaction, respectively. For further studies, cross-lagged correlations and nonrecursive models will be introduced in the work satisfaction-life satisfaction relationship model.

Keywords: Repatriation adjustment, repatriation failure, work satisfaction, life satisfaction

INTRODUCTION

Accompany with globalization, more and more organizations sent out employees overseas for varied reasons and for different length of time. When those employees accomplished their missions overseas, they had to return home countries. Based on studies in the past, repatriation adjustment took time and the percentage of repatriation failure was high. Allen & Alvarez [3] stated that there are three costs of repatriate failure for organization: loss of key personnel, underutilization of repatriates, and difficulty of recruiting future expatriates. Therefore, the providing of effective repatriation assistance to employees and their family members is necessary. However, based on previous studied, not much MNCs have formal repatriation policies or process to assist repatriates and their family [17][26][31].

In the other hand, there are lots of research on work satisfaction and life satisfaction, and some are on the relationship between them [8][18][21][27][20][28][30]. Findings have concluded that work satisfaction and life satisfaction are related to each other and both have impacts on turnover rates, job performance, and so on. However, not much literature have focused on the work satisfaction of repatriates and on the life satisfaction of repatriates’ family.

Moreover, even though many articles have tried to explain the expatriates and spouse adjustment during their oversea missions [6][24][37], and some studies has focused on the repatriation policies and process [2][14][15][19], only few researches have discussed the relationship of repatriate adjustment and spouse adjustment [15][16]. Repatriate adjustment and spouse adjustment may affect work satisfaction of repatriates and life satisfaction of their family, and further affect the company.

Therefore, in this study, we intend to explore the relationship between work satisfaction of repatriates and the life satisfaction of their family members, and find out how repatriation assistance provided by organizations can help them.

The rest of the study is organized as the following. Literature review is in the next section, followed by the discussion of the methodology applied to the study. The section of results and analyses presents in the next. Conclusions and suggests are presented in the last.

LITERATURE REVIEW

Work satisfaction and life satisfaction

People evaluate the fulfillment of their goals, needs and wishes in their daily life and the subjective evaluation decides their life satisfaction [12][10]. Most of life satisfaction studies have paid attention on the adults [10], undergraduates students [5][11][38] and elders [25], but not much on life satisfaction of repatriates family.

Iverson & Maguire [18] mentioned that there have been three theoretical models trying to link work satisfaction and life satisfaction. Those were on spillover, compensation and segmentation perspectives. The spillover model asserted a positive relationship between work satisfaction and life satisfaction [36], but debated on the directions. Schmitt & Mellon [30] declared a ‘spillover’ effect of life satisfaction to work satisfaction [20]. However, in the other hand, Adams et al [1] found that work satisfaction had a stronger effect on life satisfaction than vice versa [8][21][28]. Moreover, the spillover model implied that life-work satisfaction and work-life satisfaction cannot happen at the same time [29].

The compensatory model concluded a negative relationship between work and life satisfaction. George & Brief [13] asserted that an unhappy employee would seek a happier non-work life to compensate his/her miserable work life. Beside supporting the negative relationship between work and non-work satisfaction, Lusopo [23] believed that it was from work to non-work direction. The third model
believed that employees would separate their work and non-work life and therefore there is no linkage between work satisfaction and life satisfaction.

**Repatriation adjustment**

It is common nowadays to assign high-level employees to abroad for MNCs. They can gain international knowledge and share the experience with colleagues in parent company upon returning home country. However, based on the research in the past, the repatriation adjustment was not easy. The process generally takes about 1 to 1.5 years [22]. Therefore, high percentage of repatriates left the parent company within two years of returning home country. That is, repatriation failure increases the turnover rate of repatriates.

Besides that, Allen & Alvarez [3] indicated the other two costs of repatriation failure. The first cost is the opportunity cost of underutilizing the international experience of repatriates. The second cost is unable to recruit key employees for future foreign assignments due to negative image in failed repatriates.

Three dimensions of repatriation adjustment have been studied: the dimension of work adjustment, socio-culture adjustment, and psychological adjustment. The work adjustment included the adjustment of being less responsibility and having less financial returns than expatriate position upon return home country. The socio-culture adjustment involved life style adjustment, relationship adjustment and financial condition adjustment. The psychological adjustment concerned the problems causing by different expectations and stress [9][19][35].

In addition, Gregersen & Stroh [15] studied Finnish spouse repatriation adjustment. The reversed culture shock hit the spouses hard. It was worse than the culture shock of host country to the spouses. The study found that unexpected changes in inter-personal relationship and housing conditions, and international experience being ignored or envied have made spouse repatriation adjustment more difficult.

Nevertheless, very few MNCs have offered formal repatriation assistance to repatriates and their family, either before or after they completed assignment abroad [17][26][31].

The proposed relationships among repatriates work satisfaction, family members’ life satisfaction, and repatriation assistance are shown in Figure 1.

We formed hypotheses as the follows:

- **H1**: Repatriation assistance positively and significantly affected repatriates’ work satisfaction.
- **H2**: Repatriation assistance positively and significantly affected the life satisfaction of repatriates’ family.
- **H3**: Repatriates’ work satisfaction positively and significantly affected their family members’ life satisfaction.

The proposed model of the relationships among repatriates work satisfaction, family members’ life satisfaction, and repatriation assistance is shown in Figure 1.

**METHODOLOGY**

**Sampling and Procedure**

For difficulty of contacting with those who worked oversea for government and still work in public sectors in Taiwan, questionnaires were sent out by convenience sampling via friends directly and indirectly. 180 questionnaires were sent out in total. With a response rate of 58.33%, 105 returned questionnaires were completed and usable.

Of the respondents, 83.8% were males and 16.2% were females; 4.8% were aged under 25, 26.7% were aged 26-30, 37.1% were aged 31-35, 15.2% were aged 36-40, 10.5% were aged 41-45 and 5.7% were aged 46-50. In terms of marital status, 62.9% of the respondents were married and 37.1% of the respondents were single. In terms of occupational status returned country, 35.2% were journal-level employees, 56.2% were middle-level managers, and 8.6% were upper-level managers. In terms of the length of sojourn, 12.4% were 1/2 year, 29.5% were 1 year, 39.0% were 2 years, 15.2% were 3 years, 1.0% were 4 years, and 2.9% were 5 years and above. In terms of the area of staying, 20% were in the European, 27.6% were in the America, 43.8% were in the Asia, and 8.6% were in the other areas.

**Measurements**

Respondents were asked to use Likert’s 5-point scales (from 1 as “extremely unsuccessful” to 5 as “extremely successful”) to answer the questions in the questionnaire, except for the personal information, such as gender and marital status.

Repatriation assistance was measured with nine questions in the questionnaires. Four of the nine questions were related to work assistance measure. For instance, including “Domestic work opportunities/ information were provided by government prior to repatriation” and “Assist with getting information of promotion opportunities prior to repatriation” were used to measure the work assistance. The rest of the nine questions including “The information regarding to children’s education was provided prior to repatriation” and “The information of work opportunities for spouse was offered prior to repatriation” were used to measure life assistance. The Cronbach’s alpha for reliability of the repatriation assistance measure for the present sample was 0.880.
In the questionnaires, we used fourteen questions to measure work satisfaction. The seven of them including “New occupational status meets my expectation” and “The expatriate experience helps to get promotion” to measure objective satisfaction and seven questions including “The expatriate experience helps on communication at work” and “The expatriate experience helps on improving relationship with colleagues” to measure subjective satisfaction. The Cronbach’s alpha for the scale of work satisfaction was 0.914.

Seven questions were used in the questionnaires to measure family members’ life satisfaction. Five of them including “The experience of expatriation helps family members to get better global views” and “The expatriate experience helps family members to be with better ability on language” were used to measure abilities progressing. The rest two questions including “The expatriate experience helps spouse on career development” and “Family members have never suffered by cross-culture difficulty in home country” were used to measure conflicts decreasing. The Cronbach’s alpha for the measure was 0.841.

RESULTS AND ANALYSES

The Pearson correlation coefficients of repatriation assistant measure, work satisfaction measure, and family members’ life satisfaction measure are summarized in Table 1. Based on the results in Table 1, we conclude that repatriation assistance measure and work satisfaction measure are positively and significantly correlated at the 0.001 significant level; repatriation assistant measure and family members’ life satisfaction measure are positively and significantly correlated at the 0.001 significant level; the work satisfaction measure and family members’ life satisfaction measure are also positively and significantly correlated at the 0.001 significant level. In one word, the three measures are positively and significantly correlated to each other in statistical sense.

**TABLE 1. PEARSON CORRELATION COEFFICIENT, CRONBACH’S ALPHA AND KMO VALUE**

<table>
<thead>
<tr>
<th></th>
<th>Cronbach’s Alpha</th>
<th>KMO 1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repatriation Assistance</td>
<td>0.880</td>
<td>0.880</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Work Satisfaction</td>
<td>0.914</td>
<td>0.893</td>
<td>0.433***</td>
<td>1</td>
</tr>
<tr>
<td>2. Family members’ Life Satisfaction</td>
<td>0.841</td>
<td>0.854</td>
<td>0.672***</td>
<td>0.349***</td>
</tr>
</tbody>
</table>

**Correlation is significant at the 0.001 level (two-tailed).**

In order to find out the causal relationship of the three measures, multiple regression models are used in the study. The estimates of coefficients for work satisfaction are summarized in Table 2. Based on the results in Table 2, both beta coefficients of objective satisfaction model and of subjective satisfaction model are positive and significant.

Hypothesis 1, therefore, cannot be rejected in our sample. The F-values are 1103.47 (p < 0.001) and 705.25 (p < 0.001) for objective satisfaction model and subjective satisfaction model, respectively. The R-square is 95.5% for objective satisfaction model and is 93.2% for subjective satisfaction model. The statistics indicates that the work assistance measure and the life assistance measure can explain both objective work satisfaction and subjective work satisfaction extremely well. Moreover, the largest beta coefficient is life assistance measure for both work satisfaction models. They are 0.631 (p < 0.001) and 0.643 (P < 0.001), respectively.

We conclude that, in our sample, work assistance and life assistance both contribute to work satisfaction of repatriates. Nevertheless, life assistance contributes more to work satisfaction of repatriates.

**TABLE 2. ESTIMATES OF COEFFICIENTS FOR WORK SATISFACTION MODELS**

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Work satisfaction</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Objective satisfaction</td>
<td>Subjective satisfaction</td>
</tr>
<tr>
<td>Work assistance</td>
<td>0.319**</td>
<td>0.382**</td>
</tr>
<tr>
<td>Life assistance</td>
<td>0.631***</td>
<td>0.643***</td>
</tr>
<tr>
<td>F value</td>
<td>1103.47***</td>
<td>705.25***</td>
</tr>
<tr>
<td>R²</td>
<td>0.955</td>
<td>0.932</td>
</tr>
</tbody>
</table>

*p<0.05  **p<0.01  ***p<0.001*

The estimates of coefficients for life satisfaction of repatriates’ family are summarized in Table 3. Based on the results in Table 3, both beta coefficients of abilities progressing model and of conflicts decreasing model are positive and significant. Hypothesis 2, therefore, cannot be rejected in our sample. The F-values are 1791.83 (p < 0.001) and 502.87 (p < 0.001) for abilities progressing model and conflicts decreasing model, respectively. The R-square is 97.2% for abilities progressing model and is 91.0% for conflicts decreasing model. The statistics indicates that the work assistance measure and the life assistance measure can explain both abilities progressing and conflicts decreasing life satisfaction of repatriates’ family models extremely well. Moreover, the largest beta coefficient is life assistance measure for both life satisfaction of repatriates’ family models. They are 0.855 (p < 0.001) and 0.497 (P < 0.001), respectively.

We conclude that, in our sample, work assistance and life assistance both contribute to life satisfaction of repatriates’ family. Nevertheless, life assistance contributes more to life satisfaction of repatriates’ family.

**TABLE 3. ESTIMATES OF COEFFICIENTS FOR FAMILY MEMBERS’ LIFE SATISFACTION MODELS**

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Family members’ life satisfaction</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Abilities progressing</td>
<td>Conflicts decreasing</td>
</tr>
<tr>
<td>Work assistance</td>
<td>0.202**</td>
<td>0.307**</td>
</tr>
<tr>
<td>Life assistance</td>
<td>0.855***</td>
<td>0.497***</td>
</tr>
<tr>
<td>F value</td>
<td>1791.83***</td>
<td>520.87***</td>
</tr>
<tr>
<td>R²</td>
<td>0.972</td>
<td>0.910</td>
</tr>
</tbody>
</table>

*p<0.05  **p<0.01  ***p<0.001*

The results of work satisfaction-family members’ life satisfaction models are shown in Table 4. All beta
coefficients are positive, but only the subjective work satisfaction measure is significant at the 0.001 level. The F-values are 951.230 (p < 0.001) and 732.624 (p < 0.001) for two life satisfaction of repatriates’ family models. The R-square is 94.9% for abilities progressing life satisfaction model and is 93.4% for conflicts decreasing life satisfaction model. This statistics indicates that objective work satisfaction measure and subjective work satisfaction measure can interpret both family members’ life satisfaction models extremely well. We conclude that, in our sample, subjective work satisfaction contributes to family members’ life satisfaction. **We cannot reject Hypothesis 3 in our sample.**

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Family members’ life satisfaction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Abilities progressing</td>
</tr>
<tr>
<td>Objective satisfaction</td>
<td>0.172***</td>
</tr>
<tr>
<td>Subjective satisfaction</td>
<td>0.886***</td>
</tr>
<tr>
<td>F value</td>
<td>951.230***</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.949</td>
</tr>
</tbody>
</table>

**CONCLUSIONS AND SUGGESTIONS**

In a globalized world, more and more organizations have sent out employees abroad for assignments. For a successful expatriation, organizations have to give their employees supports in varied stages during their international assignment. Throughout the expatriation in host countries, expatriates have accumulated international knowledge. Hopefully, they can contribute the international experience to parent companies after they completed the foreign assignments and return to home country. However, a huge percentage of those expatriates have left their parent company shortly after they return home country. And yet, this costs money!

In this paper, we intended to study the relationship among repatriation assistance, work satisfaction of repatriates, and life satisfaction of repatriates’ family. By sending out 180 questionnaires to repatriates and their family in a Taiwan’s public institute, with a response rate of 58.33%, we found out that work satisfaction of repatriates positively and significantly affected life satisfaction of repatriates’ family. Especially, subjective work satisfaction contributed more on life satisfaction of repatriates’ family. Probably, in our sample, repatriates concerned more on subjective work satisfaction, like “expatriate experience improves professional ability,” and therefore had strong effects on the life satisfaction of their family.

We also found that repatriation assistance positively and significant affected the work satisfaction of repatriates and the life satisfaction of repatriates’ family. Particularly, in our case institute, life assistance had stronger effects on both work satisfaction and life satisfaction. That is, in our sample, repatriates and their family appreciated more on the life assistance offered by the institute. Therefore, when MNCs set up formal repatriation policies and process, they should pay more attention on those of life assistance.

There are few more issues can be dressed in this study, if there were more financial support and time, such as, nonrecursive models and cross-lagged correlations. Introducing nonrecursive models into life satisfaction and job satisfaction models can decrease the debates of direction of job-life satisfaction and life-job satisfaction.

In addition, Orpen [27] and Schmitt and Mellon [30] introduced cross-lagged correlations into their studies for job satisfaction-life satisfaction relationship. This can be done for further studies.

**REFERENCES**


Strategic Responses To CSR Reporting: Evidence From The Conformity Of GRI Guidelines In Australian Mining And Banking Industry

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Huei-Yin Chou, Mei-Ho University of Technology, Taiwan, hueiyin57@gmail.com

ABSTRACT

This study aims to identify the different strategic responses that corporations enact in the adoption of GRI guidelines in corporate social responsibility (CSR) or sustainability reporting in the Australian context. The social and environmental accounting (SEA) literature indicates that there are many theories underpinning the reasons for voluntary corporate social and environmental disclosure (CSED). Some scholars [1-2] criticize that managerial capture actions exists in the corporate engagement of CSR/sustainability reporting. This study investigates how managerial capture is advanced in CSR/sustainability reporting by means of the adoption of the GRI Sustainability Reporting Guidelines (the GRI Guidelines) in Australian banking and mining industries.

Keywords: Sustainability reporting, CSR, GRI Guidelines, managerial capture

Introduction

The purpose of the study is to identify the different strategic responses that corporations enact in the adoption of GRI guidelines in CSR or sustainability reporting in the Australian context. CSR is not a new issue; however, as noted by Votaw [3, p.25] in more than three decades ago, ‘corporate social responsibility means something, but not always the same thing to everybody’. The concept CSR has been emerging in business for many years but has gained greater prominence in the last decade. Recently Dahlsrud [4] conducted an extensive review of literature from 1980 to 2003 and found thirty definitions from twenty seven authors. Employing a content analysis to coding these sources from Google, Dahlsrud [4, p.7] depicts several top definitions in frequency count. Some of the CSR descriptions focus on compliance with related law, while others concentrate on the social impact of corporate activities and commitment on stakeholders. Much of the debate about CSR has been centered on the merit of the ‘shareholder primacy principle’ and broader stakeholder prospective.

Within the trend towards sustainable development, a central theme in business is non-financial risk management and disclosure [6-7]. The key concern is whether current disclosure rules are adequate to require large corporations to provide sufficient publicly available information, for the benefit of investors and other interested parties, regarding their policies and practices in relation to the environmental and social impacts of their operations. Addressing this issue, two principal accountability and reporting frameworks have been developed: the Global Reporting Initiatives (GRI) Guidelines and the AccountAbility 1000 series [8]. The GRI Guidelines provide a generally recognized and adopted voluntary reporting standard (Sustainability Reporting Guidelines) that organizations can apply when reporting their performance in sustainable practices. The AccountAbility 1000 (AA1000) Series is used to guide corporations in establishing a process for engaging with their stakeholders. It is used to deal with the process of independent verification of triple-bottom-line reports, and provides an audit/assessment framework and protocol designed to complement the GRI Guidelines and other standardized or company-specific approaches to disclosure. The social and environmental accounting (SEA) literature indicates that there are many theories underpinning the reasons for voluntary corporate social and environmental disclosure (CSED) [see review papers, such as 9, 10]. Some scholars [1-2] taking a critical approach, assert that the voluntary CSED cannot be viewed as an exercise in accountability. Instead, they criticize that managerial capture of CSR actions exists in the corporate engagement of CSR/sustainability reporting. Among these scholars, the term ‘managerial capture’ means that corporations, through the actions of their management, take control of the debate over what CSR involves by attempting to create their own definitions [12]. However, few of these researchers take from an institutional perspective [13] to investigate how the strategic behaviors employed to conform to external guidelines that affect those corporations.

This study investigates how managerial capture is advanced in CSR/sustainability reporting by mean of the adoption of the GRI Sustainability Reporting Guidelines (the GRI Guidelines) in Australian banking and mining industries. The GRI Guidelines are motivated by a desire to provide corporations with a better CSR/sustainability reporting framework. It is argued that the guidelines are to be facilitating transparency and accountability in corporate practices as well as increasing comparability of CSR/sustainability reports [14]. However, the adoption of the GRI Guidelines in CSR/sustainability reporting and the application level of the guidelines are optional. Given this, it might be interesting to empirically investigate why corporations report and how they use any external guidance when preparing the reports. Consequently, the initial form of the research questions arising from this problem related to: 1) why there is a need for corporations to engage in voluntary...
CSR/sustainability reporting: 2) and how managerial capture relates to GRI reporting in terms of the variation between industries and companies. The remainder of the paper is structured as follows. The following section reviews a number of theories underpinning the reasons for voluntary corporate social and environmental disclosure. Highlighting the link between the research questions and the design, a multiple-source data collection and multiple-approach data analysis is then furnished. Why and how corporations respond to social pressures and economic rationale in their CSR/sustainability reporting is subsequently presented and delineated the motivations and nature of industries-mining and banks. This is followed by a discussion of findings and considerations of implications and limitations of the research and findings. Finally, directions and opportunities for future research are included.

Theories Underpinning Voluntarily CSR/Sustainability Reporting
Accounting literature has identified five voluntary disclosure theories, which purport to explain why corporations engaged in voluntary CSR/sustainability reporting: agency theory (AT), signal theory, legitimacy theory, stakeholder theory, institutional theory [15]. Drawing on accounting literature, Healy and Palepu [16] indicates that companies would limit their voluntary disclosure because of possible litigation and proprietary costs. But why do companies have incentives to engage in CSR reporting? Information asymmetry between agents and principles may lead to two specific types of agency problem, moral hazard and adverse selection [17]. Managers who anticipate making transactions in the capital market have incentives to provide voluntary disclosure to mitigate the information asymmetry problem so as to avoid moral hazard and adverse selection. By doing so, managers attempt to reduce the cost of external financing. However, the market-based motives based on agency theory cannot provide a satisfactory explanation for CSED. Based on agency theory, in the context of CSED the principal would be society or certain groups of stakeholders and the agent is the corporation. Apart from agency theory, social-based theories provide another perspective on CSED as they explicitly recognize that organizations evolve within a society that encompasses many political, social and institutional frameworks.

Legitimacy theory, derived from the concept of organizational legitimacy, is possibly the most pervasive type [18, p. 846] of research into motivations underlying CSED. Legitimacy can be understood as the confirmation of societal norms, values and expectations. Legitimacy problems (disparities) are said to occur when societal expectations for corporate behavior differs from societal perceptions of a corporation’s behavior. The existence of a widening legitimacy gap drives corporate efforts to manage legitimacy. Such threats could be evidenced through the fluctuations on the capital market, a boycott of products, or the legal requirements of governmental bodies. Legitimacy theory, originated in the concept of the social contract, suggests that companies engage in CSED because of the need to manage the ‘legitimacy’ of the company [9].

Manage Organizational Legitimacy in CSR Reporting
Drawing on the above discussion, legitimacy can be defined as ‘a generalized perception or assumption that the actions of an entity are desirable, proper or appropriate within some socially constructed system of norms, value, beliefs, and definitions’ [19, p.574]. This broad definition is used to capture not only the institutional view of legitimacy adopted by Meyer and Rowan [20], but also the strategic view adopted by others, like Dowling and Pfeffer [21]. The first view is interested in environmental dynamics becoming constitutive of organizational life and structure. From a legitimacy management perspective, companies voluntarily engage in CSR/sustainability reporting to demonstrate how their operations adhere to norms or expectations of the society. In the second view, Meyer and Rowan [20] further explained how the rationalized meanings (or myths) attached to organizational structures or practices gained legitimacy. Meyer and Rowan [20] argue that legitimacy or social fitness is gained or maintained through ‘rational myths’. The myths are a prescription generally accepted as being true because of their highly institutionalized nature; nevertheless they are largely untested. Meyer and Rowan [20] stated that rationalized myths are a kind of institutional rationality that guides individual behavior. These rational myths include procedures or organizational structures within a certain industry. By adopting a formal structure that adheres to the prescription of myths in the institutional environment, an organization demonstrates that it is acting in a proper and adequate manner. In contrast, organizations that fail to incorporate these rationalized myths seem ‘negligent and irrational’ [20, p.350]. The GRI Guidelines are used as a symbol to manage the expectations and perceptions of stakeholders in CSR/sustainability reporting. The GRI Guidelines, as a set of globally recognized guidelines in CSR/Sustainability reporting practice, can be viewed as a sort of ‘rational myth’, by which an organization may try to confer legitimacy on itself by adopting it. A company may use the adoption of the GRI Guidelines in the production of CSED to indicate to its stakeholders that it is serious about its CSED. By doing that, a company may enhance the credibility of its CSR/sustainability report and facilitate its social and environmental reputation. To address stakeholders’ concerns about the credibility of CSR/sustainability reports, the GRI Guidelines offer a self-declared compliance system and encourage reporting entities to seek an independent assurance from a third party. With AA1000 and ISAE 3000, the independent assurance practitioner can verify the self-declared compliance level with the GRI Guidelines. Thus, a reporting entity could enhance the credibility of its sustainability report. However, the adoption of the GRI Guidelines in CSR/sustainability reporting and the application level of the guidelines are optional. Given this, it might be interesting to empirically investigate why corporations report and how they use any external guidance when preparing the reports. The particular pattern that the current study is interested in how the managerial capture involved in CSR reporting while managers perceived the propriety costs may incur.

Research Method
A comparative-case study approach [22] is thus utilized to reexamine the relationship among the perception of managers in respect of the social and environmental pressures on companies, the motivation for voluntary
disclosure, disclosure strategy and the outcome of CSR/sustainability reporting (in particular, the application level of adoption GRI Guidelines in reporting themes, the issues and the key performance indicators). Theoretical sampling has been applied in selecting corporations for interviews to highlight theoretical issues and to refute or challenge the theory being tested (Eisenhardt, 1989). Consequently, maximum variation strategy (Kuzel [23], cited by Mile & Huberman, 1994, p.28) is applied in the corporation selection. ‘Maximum variation’ refers to looking for outlier cases to see whether main patterns still hold. Guba and Lincoln [24] advocated that maximum variation strategy is a deliberate hunt for negative instances or variation.

Case Companies Chosen
The companies in comparison include five mining companies and three financial service companies. Industry and size are two key factors influencing CSR reporting of these companies [25]. The first design is a between-group comparison, which focuses the difference between companies in different industry (mining vs. banking). BHP and ANZ are viewed benchmarks in the respective industries. The second comparison is a within-group (inter-sector) design. The size of the companies in the same industry is the focus of the comparison. M1 is compared to M2 and M3 is compared to M4. Since the size of the banks is large, no small size within-group comparison had been made for banks.

Table 1 An Experimental Design in A Case Comparative Approach

<table>
<thead>
<tr>
<th>Design 1</th>
<th>Between-Group Design (factor: industry)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groups</td>
<td>Mining Industry</td>
</tr>
<tr>
<td>Case Company</td>
<td>BHP Billiton (Benchmarking)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Design 2</th>
<th>Within-Group Design (factor: size)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groups</td>
<td>Large</td>
</tr>
<tr>
<td>Case Company</td>
<td>M1</td>
</tr>
</tbody>
</table>

Data Collection
A multiple-stage data collection approach is employed. Data were collected from interviews with management from companies and secondary data. Semi-structured interviews were conducted with senior officers, responsible for corporate sustainability/CSR reporting in the selected companies. A total of 7 interviews with 8 senior officers about CSR reporting were undertaken among two Australian banks and four Australian mining companies from May to August 2008. Although the semi-structured interview method used in this project is rich in heuristic potential, it may be subject to the bias of intrusive effects caused by the interviewer during the interview or in the later data analysis. In order to ensure the credibility of theory building and refining, as recommended by Lillis [26, p. 84-85], some tactical approaches were used to limit the bias in the data collection and analysis: 1) an interview sheet; 2) structured questions; and 3) a systematic auditable process. The interviews were conducted in three steps. The first step, an “experience survey” [27, p. 55-59] was employed. In this step, informants were asked to describe generally their companies and their operation, their titles or roles in the range of disclosure processes to which they had been exposed. The second step covers the first part of “focus interview”. In this step, the interviewer attempts to understand the motives for companies to engage in CSED. The third step covers the second part of the ‘focus interview’ which focuses on the process of CSED, how the case companies respond to these stakeholders (audience) in the light of their information needs. Based on the framework of Gibbins et al. (1990), the interviewer unfolded the questions in an interview sheet which includes open-ended questions cover the following topics: 1) organizational constituencies involved in the decision-making of CSR reporting; 2) the process that the company uses to decide the format, the content (issues and performance indicators) and the application level (if the GRI Guidelines is adopted); 3) the role of consultants, auditors in the process of CSED; and 4) impacts of the adoption of GRI Guidelines in CSED practice. The interviewer tried to keep the questions open-ended and short in an effort to allow the informants to do most of the talking. In order to ensure that interviewees’ commentaries were focused on the motives of CSR reporting and the topics related to disclosure process, the interviewer remained inquisitive but not intrusive throughout. The interviews, lasting from 60 to 90 minutes, were digitally audio-recorded with the permission of each interviewee. The digitally audio-taped interviews were transcribed using a professional transcription service. Then copies of the transcripts were sent to interviewees to verify the accuracy of the transcripts. No significant changes were made by any interviewees to the transcripts which had been given to them.

CSR/sustainability reports issued by the case companies were used to double check what the management said in the interviews. This provides multiple-resources auditing to ensure whether or not the social pressures and responses revealed by the interviewees match with the output of their CSR/sustainability reports. Thirty-five copies of CSR (sustainability) reports released by the corporations selected were obtained through companies’ website or website database1. BHP and ANZ were not companies interviewed, but as they are seen as benchmarking companies in CSR reporting in their industries, their CSR (sustainability) reports are included. The period is from 2002, when the more sophisticated GRI Guidelines (GRI 2002) were released. The selection criteria are subject to comparability and consistency in data analysis. Data in the CSR reports of the selected corporations also provided background information for the interviews. As indicated by Scandura & William [28, p. 1249], researchers could have obtained better understanding of their research issue by approaching from multiple references. The multi-stage data collection is designed to facilitate the understanding of the phenomenon, while also providing triangulation.

Data Analysis
In the light of the research purposes and research questions, content analysis and analytical induction methods were utilized for the current study. An index content analysis coding scheme was applied to the parts of performance indicators in CSR/sustainability reports. Based on G3 (GRI 2006), the disclosure can be divided into two parts—Profile

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1 (http://www.corporateregister.com)
of the Company and Sustainability Performance Indicators. The performance indicators are divided into six categories and these categories are as follows: (1) Environmental, (2) Human Rights, (3) Labor Practices and Decent Work; (4) Society; (5) Product Responsibility; and (6) Economic. Since the purpose of the current study is to tell the differences in CSED, in particular in report profiles, disclosing issues and their related key performance indicators, the index developed for the content analysis focuses on the performance indicators. Clarkson et al. (2008) argue that the design in ‘hard’ discography categories makes it relatively difficult for firms with poor performance to mimic the disclosures of firms with good performance. With the test of the index (‘0’ for no existence of the indicator; and ‘1’ for the existence of indicator), it is easy to tell the difference between substantive compliance and symbolic compliance. The analytical induction approach was employed to collect the data from interviews among the selected companies. This process focuses on data reduction, data display and conclusion drawing/verification, and interpretation to make sense of the unedited text. Drawing on the previous work, Gibbins et al.,[29] developed a mixed procedure which combined analytical induction and grounded theory methods. This procedure is simplified to an analytical induction one, and used in data analysis (see Appendix 1).

Results and Discussion

The findings explain the phenomena observed. Australian mining companies and banks report differently in voluntary CSR reporting; and this shed light on a theoretical issue: why organizations in similar organizational field pursue heterogeneous practices. The findings assume that companies adopt a heterogeneous set of CSED because the firms perceive social pressures differently, and this leads to different CSED. The disclosure forms and contents reflect the perceived target audience and their information needs subject to sector and organizational characteristics. Appendixes 2 and 3 provide a summary of the findings including quotations of selective representatives, and can be used as a road map for the remainder of the section.

Motives to Engage in CSED

Management motivation for CSED is first discussed; in particular, the managers’ industry-specific needs are considered. Data analysis provides evidence that managers do perceive social and environmental pressures in the organizational field. Of the interviews from the six corporations in Australian mining companies and banks, the managers in charge of CSR/sustainability reporting stressed that they had to deal with social and political pressure that possessed the potential to damage organizational legitimacy and that may end by damaging economic interests. First, CSED managers perceive a high level of scrutiny from groups or individuals. Second, they perceive an increasing regulation in the operational field.

Strategic Responses to Political and Social Pressure

Responding to this, both industries have strong industry associations and codes of conduct in the context of sustainability. It is clear that the responses from interviewees emphasize that CSED managers perceived that their industries or corporations were under the pressure of social scrutiny and this could lead to facing an increasingly regulated environment. These issues are critical to companies’ ‘survival’. Responding to these issues appropriately is a matter of obtaining a ‘social license to operate’ for companies. In response to these pressures, industries or firms can develop their own sustainability initiatives or comply with some external ones to show their commitment to sustainability. GRI is one of these external sustainability initiatives providing Guidelines for CSR reporting. What if companies do not respond to the above social pressures appropriately? Most respondents perceived that without responding to these threats appropriately, the industry or firm may become a political target and this threatens their ‘license to operate’ in society. Finally these pressures can threaten the survival of the business.

Banking Sector’s Competition over Sustainability

However, it is worth noting that apart from perceived social and environmental pressure, the case-companies in the banking sector believe that competition over sustainability exists in the industry and sustainability is an opportunity to yield market growth. This industry-specific need for CSED apparently has shifted the issue of sustainability from a threat to an opportunity [30]. CSED managers in the banking sector also believed that their pressures come from market competition in relation to sustainability. ‘Competition’ here refers to the fact that CSED is used to improve a company’s competitive advantage, and then to benefit the company’s long-term profitability. With the trend towards sustainability, Australian banks are not only concerned with their organizational legitimacy but are also thinking about how to take advantage of sustainability as a competitive edge in the market growth. Press reports about how ‘banks seek greener pastures to win eco advantage’ (Sydney Morning Herald 20/09/2007, p.31) can be seen occasionally, and ANZ is eyeing sustainability investment as the next big growth market and has set up an investment vehicle aimed at funds from the non-profit and government sector (The Age, 02/11/2006, p.2). When the respondents were asked whether or not competing companies actively promote their CSR reports, interviewees in banks confirmed this statement and discussed how their rivals use CSR reporting (in particular, verified sustainability reports) as a tool to promote their performance in relation to sustainability. Most major Australian banks reflect these expectations and respond by the adoption of the GRI Guidelines with high application level in their CSR reports.

The Variation of the Report Profile

Different perceptions lead to various CSED. This section provides findings from the content analysis of CSR/Sustainability reports from the companies interviewed plus the reports from a leading company in each industry group not interviewed; BHP Billiton Ltd-Mining and ANZ Ltd-Banking. The evidence is shown in three levels: the report profile chosen, the issues concerned and the KPIs selected. Finally, the adoption of KPIs was used to show the limited disclosure of the case companies. From a strategic approach perspective, the information relevant to main stakeholders and the consideration of proprietary costs influence the decision-making of limited disclosure in voluntary CSED. It is obvious that when most organizations...
face a conflict between their financial performance and their social and environmental performance, they are bound to give preference to the financial. The above conception reflects that GRI reporting is self-interest responsiveness to social involvement which implies the exhibition of a social responsibility to accountability. CSR reporting in this form is ‘made well within the establish framework of the traditional enterprise where economising is dominant over other social value [cited by 12, p.19]. Triple bottom line reporting (TBL) after all is a financial bottom line with a little bit of social and environmental added [31].

Implication and Contribution

The paper makes a number of contributions to SEA literature and CSR reporting. First, the current study represents a rare example to have examined strategic responses to the adoption of the GRI Guidelines in CSR/sustainability reporting via semi-structure interview in the Australian context. In doing so, the current study responds to the calls of Adams and Larrinaga-Gonzalez [32] and Gray [33] to conduct engagement research in CSED. Secondly, the current study provides an opportunity to observe how the ‘managerial capture’ [12] of voluntary CSR/sustainability reporting is conducted in particular institutional contexts, Australian mining and banking sectors. This responds to the call to examine more specifically how managerial capture works in a set of specific social and environmental initiatives [34]. Additionally, by adding a strategic approach to identify the main audience (stakeholders) of CSED and by adding an institutional approach to clarify public expectations, the current study adds to the rich data sets, provided by qualitative studies, to illustrate more clearly the subtle nature of managerial capture.

Acknowledgement

This article is based on Andrew’s PhD thesis at the School of Accounting and Corporate Governance at University of Tasmania. Andrew offers special thanks to my supervisors, Professor Gary O’Donovan and Professor Robert Clift. We also would like to thank Dr. Jen-Yin Yeh, the track chair of Cases, Workshops, and Special Sessions of the Conference for her helpful comments of this work. All errors and omissions remain our own.

References


Appendix 1 Flowchart of the Coding Procedure

<table>
<thead>
<tr>
<th>Flowchart</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Select the case</td>
<td>1. One of the edited interview transcripts is selected as the first “case” to be analyzed. The current study stared from a company in mining industry.</td>
</tr>
<tr>
<td>2. Highlight significant words/phrases</td>
<td>2. The ‘significant’ words and phrases in the transcript are highlighted. The significant words or phrases succinctly capture aspects of the case which may be used to understand or explain the needs, process and organizational fit of CSED. Two types of phrases were regarded as significant; a phrase by which the informant attempts to make sense of the phenomenon and a phrase by which researchers can link cases to their prior knowledge.</td>
</tr>
<tr>
<td>3. Sorting highlighted words/phrases into categories</td>
<td>3. The highlighted phrases are sorted into the categories based on the intuitive sense of similarity. At the same time with this process, the author noted any relationships which may exist in the data. The relationship may be suggested explicitly by an interviewee or may emerge inductively as the researcher attempts to make sense of the transcripts.</td>
</tr>
<tr>
<td>4. Assign categories based on preliminary framework</td>
<td>4. In line with the preliminary framework shown in Chapter 4, the criteria used to establish the categories developed are identified explicitly; in the form of ‘free nodes’. These ‘free nodes’ were grouped into categories (‘tree nodes’) in the light of their relationships.</td>
</tr>
<tr>
<td>5. Recursively shift accumulated categories</td>
<td>5. The accumulated categories are shifted recursively. In order to identify more thematic concepts, this sort of reorganizing of categories allows the combination of two or more of empirically defined sets.</td>
</tr>
<tr>
<td>6. Re-examine data in free nodes</td>
<td>6. The categories which are logically possible but missing from the data are identified.</td>
</tr>
<tr>
<td>7. Form thematic concepts and identify their relations</td>
<td>7. The concept of the “free nodes” developed in step 3 is used to identify the central thematic concepts involved in the case. In this study, the nodes are intended to be converged into the tree nodes of needs for CSED and the process of corporate sustainability reporting practices, in particular, the adoption of GRI Guidelines. Since CSED is a voluntary disclosure, the actual disclosure may be varied with the same theme. The relationships among categories around the thematic concepts are identified.</td>
</tr>
<tr>
<td>8. Ensure the fit?</td>
<td>8. All ideas developed are confirmed to “fit” as the relationship is being refined. Repeat step 1 through 8 for a second case and then other cases in the bank sector.</td>
</tr>
</tbody>
</table>

Source: modified by the author from Gibbins et al.[29, p.39]
### Appendix 2 Key Dimensions and Motivations for CSR Reporting

<table>
<thead>
<tr>
<th>Differentiating dimensions</th>
<th>General Motivation</th>
<th>Exemplary quotations</th>
<th>Sector-Specific Need</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objects</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ends</strong></td>
<td><strong>Survival:</strong> To obtain social approval through risk management</td>
<td>Profitability: To add organizational value from reputation building</td>
<td>Economic Efficiency in Competitiveness</td>
</tr>
<tr>
<td></td>
<td>So that’s, ah, and that’s been to maintain our social licence to operate and/or gain approval to develop new projects. Just sort of, there’s some general aspects in our sustainability reporting that we look to, if you like, sell our credentials and our past performance so it’s an important tool and sometimes to assist in project approvals and gaining that initial entry into new areas for example. (mining companies)</td>
<td>I guess for us it sustainability the way we do business so it’s almost a cultural thing or certainly that’s the ambition. And it is an opportunity to position and differentiate but first and foremost it’s from the value, organisational values rather than financial value, but we do believe there’s financial value in adopting a sustainability approach (banks).</td>
<td></td>
</tr>
<tr>
<td><strong>Means</strong></td>
<td><strong>Risk Management</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>External Antecedents</strong></td>
<td><strong>Institutional Pressures</strong></td>
<td><strong>Brand/Reputation building</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Social Scrutiny/ Social Pressures</td>
<td>Competition over Sustainability</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increased Regulation of the Industry or the Firm.</td>
<td>Opportunities in Product and Capital markets</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Peer Pressures</td>
<td>Expect to gain profitability from organizational and financial values</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Become a Social Target</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Disclosure strategy</strong></td>
<td><strong>Reactive: Isomorphic/ imitative</strong></td>
<td><strong>Proactive: Innovation</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Compliance with norms and regulations ceremonially</strong></td>
<td>you know, on company in our industry can’t do anything without others knowing about it, so I think there is a lot of learning from others, adopting similar practices and ….So I think all companies are looking at doing similar things. So you wouldn’t see, you’d see some difference, so there’ll be differences between what the companies are doing but they’ll all have, I guess, similar initiatives.</td>
<td>Opportunity to increase financial or organization values</td>
<td>Yeah, so it’s a kind of value and the values, if that makes sense. I think that in terms of competitiveness, I mean, it’s of interest to, increasingly to analysts and therefore I guess it has the potential to sway capital flows into your organisation and impact on your share price over the long term.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A lot of the links between sustainability activities and financial value are still being modeled and analysts will tell you that there’s areas where they feel that these links are quite easier to demonstrate and human capital management is one area of that.</td>
<td></td>
</tr>
</tbody>
</table>
### Appendix 3 Response to Social Pressures: the Adoption of GRI Guidelines in CSR Reporting

<table>
<thead>
<tr>
<th>Sector comparison</th>
<th>Mining</th>
<th>Banking</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Issues accountable for</strong></td>
<td>Focus on the environmental issues and health and safety concerns</td>
<td>Focus on profitability and the related social issues caused by financial literacy and responsible lending</td>
</tr>
</tbody>
</table>
| **The priority of main audience for CSED** | Local communities, Employees, and NGOs
Even if we can get through all the government approvals, you know, we’ve got protestors and people in the local community opposed to our operations then it makes it really hard to operate so it’s in our interests to work with them and to communicate to them as well. | Customers, institutional investors, investment analysts and employees
Some institutional investors, particularly superannuation funds. And ESG analysts who prepare reports for some of those funds. …we certainly are having more and more discussions with them about the types of information that they would want to see. |
| **Information needs** | Take the adoption of the GRI Guidelines as a benchmark to test the relevance of a global CSR reporting standard | |
| **The GRI Application Level** | Low application level | High application level |
| **Presentation format** | Concise PDF version with comprehensive version on website | Concise PDF version with comprehensive version on website |

**Decision to limited disclosure (6.5): Limited adoption of the GRI Guidelines in CSR reporting between the case companies**

**Decision rule (1): information cost**
- Costs and risk of noncompliance
  -Yep, absolutely. We’ve had to because we call it a social licence to operate. We can’t operate as an industry without having, you know, broad community support for what we do. |
- Cost-benefit analysis
  - [A bank] and [B Bank] for example, do way more promotion around their report than we do. And they actually use corporate register xxxx service, we don’t [because of] a combination of budget and other things. |

**Decision rule (2): information relevancy**
- [we] don’t address every GRI obviously because it’s not relevant to us. Or we don’t collect verifiable information on it so it would be, so we don’t report on it. |
- Innovative
  - We report against the GRI but we also report against a number of indicators that we developed ourselves, that came as a result of a large stakeholder consultation process that were Australian specific indicators. |

**Empirical Evidence**
- The Variation of CSR/Sustainability Reports of the Case Companies:
  - Report profile
  - Disclosure Issues
  - Key Performance Indicators of the case companies
AUTHENTIC LEARNING: LEARNING SCAFFOLDING FOR STUDENTS

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ABSTRACT

Information systems and technology are critical to today’s business, especially in current e-business environment. The information systems curriculum, IS2002, not only places emphasis on technical discipline-specific knowledge, it also stresses the importance to train students in an authentic context. Authentic learning employs authentic context reflecting the way knowledge is used in real world situations. However students often encounter difficulty in achieving desired learning outcome in this type of real world problem-based learning environment. This paper describes the design of a series of learning scaffoldings to make authentic learning and group work effective.

Keywords: Authentic learning, learning scaffolding

INTRODUCTION

Information systems and technology are critical to today’s business, especially in current e-business environment. The information systems (IS) curriculum, IS2002, not only places emphasis on technical discipline-specific knowledge, it also stresses the importance to train students to possess skills that are required in real world situations such as effective oral and written communications, teamwork, problem solving and critical thinking [1]. However, this type of soft skills are generally not explicitly taught and critically assessed compare to that required of discipline-specific knowledge.

This paper describes the use of authentic learning in an information system development subject. We also describe a series of learning scaffoldings to support authentic learning and group work. The information systems development subject teaches systems development and prototyping process by evaluating and choosing an appropriate system development methodology. The subject emphasises effective communication with users and team members and all those associated with development and maintenance of the system.

We apply authentic learning principles through a shared scenario and role play to enable students to immerse in the complexities of authentic systems development tasks. The goal is to intentionally use a complex real-world scenario to bring about authentic learning outcomes to enable students to gain authentic experience working in different roles as would-be IS professionals. This way students can immerse in the complexities of authentic system development environment that reflect the way IS professionals perform systems development tasks and activities and to provide authentic context that reflect the way knowledge is used in real-life.

Students are expected to identify, use and tailor an appropriate methodology to suit the client's development circumstances. Thus the ability to gather and analyse information during project development is a skill that students are expected to gain at the completion of the subject. As part of learning outcomes, students are expected to liaise with users and have an understanding of how systems may need to evolve to match changing organisational environment. In this paper, we will discuss strategies that have been used in this subject to help students to manage their projects and to achieve better learning outcomes in problem-based learning situations.

The rest of the paper is organised as follows. Section 2 describes principles of authentic learning, section 3 presents authentic activities, and section 4 discusses scaffolding strategies that have been planned to support authentic learning environment. We present lessons learned in section 5 and concludes the paper in section 6.

AUTHENTIC LEARNING

Learning by doing is the approach that was designed for this subject. An assessment task which provides authentic learning experience for students as they explore evolutionary prototyping in the project is introduced. Authentic learning focuses on real-world problems using role-playing exercises, problem-based activities and participation in virtue communities of practice [3, 5].

Information and communication technology has changed rapidly in the last decade. The nature of this rapidly changing discipline means the professional context in which the IS graduates perform their tasks also changes rapidly. Authentic learning, which entails learning environment that is similar to real world, is an appropriate learning approach in such a rapidly changing technological world. Herrington, Oliver and Reeves [2] identify ten characteristics of authentic learning activities. The ten characteristics are problems:

- have real world relevance,
- are ill-defined,
- comprise complex tasks,
- require examination of tasks from multiple perspectives and roles,
- require collaboration,
- provide opportunity to reflect,
- are integrated and applied across subject areas,
- are seamlessly integrated with assessment,
- create polished product, and
- allow competing solutions and diverse outcomes.

In addition, Herrington [3] describes authentic learning environment having the following characteristics: an authentic context that reflects the ways knowledge is used in real world, authentic activities, access to expert performances and modelling of process, multiple roles and perspectives, collaborative construction of knowledge,
reflection, articulation, coaching and scaffolding and authentic assessment.

AUTHENTIC ACTIVITIES

The IS professionals design and implement information technology solutions for business processes in organisations by modelling organisational data and processes, define and implement technical and process solutions. In IS courses, students are motivated to learn by doing that involve real-world problems. Thus authentic learning which involves authentic activities that mirror real-world activities is designed.

The assessment of this subject is based on a major system development project using evolutionary prototyping approach. The assessment consists of four milestones representing four iterations of prototypes. Two case scenarios for two small and medium-sized companies are presented to the students. The first company specializes in placing contract and casual employees; the second company is a supplier of high quality clothing company. The students are required to develop a computer-based information system to handle day-to-day business operations. User requirements for each of the cases are intentionally vague and ill-defined to reflect the authentic context of real world situation to allow role playing and user requirement gathering to be performed in a more complex manner. The assessment criteria include analysis and design components of the system, correct modelling technique as well as accurate representation of the system based on user requirement.

The project involves group work. Students are required to form a group consisting of four individual students. Within each group, the students are further divided into two subgroups which we call team (i.e. team 1 and 2). Thus each team consists of two students. There is a dual-role playing in this assignment: the system development role and the user role. To illustrate how it works, consider an example of a group with team members A, B, C and D. Team members A and B are assigned to team 1 and C and D are assigned to team 2. In this example, team 1 takes the role of user for the first company (recruitment consultant) while team 2 acts in the role of system developer for this company. In a similar manner, team 2 takes the role of user for the second company (clothing company) while team 1 operates as the system developer.

This arrangement of dual-role playing allows the students to investigate the learning environment from more than one perspective. The role playing of user provides an opportunity for the students to act in a role that does not normally take place in their day-to-day work. When the students are in the user role, they are required to study the case scenario and describe to the system developer what the broad requirements of the system are. Students are being told that the case scenario given is intentionally vague and they are required to define the system objectives and communicate their system requirements to the system developer. Similarly students who act in the system developer role are required to consult the users on the requirement of the system and develop the new system based on the requirements as specified by the users.

SCAFFOLDING STRATEGIES

By employing authentic learning philosophy without cultivating skills that help students to achieve learning outcome is undesirable. This section describes several learning scaffolding strategies to help students in achieving the desired learning outcomes. Lombardi [5] has explained that students want to be let in on teacher’s thinking process, for example why the assessment was designed in this manner, what the teacher is trying to accomplish, why the learning activities are relevant, and what the criteria are for assessment. By providing learning scaffolds in the form of templates as shown below, we aim to help students to understand the assessment and learning process.

Firstly, we develop a project timeline to help students to manage their project. Figure 1 gives an example of broad project timeline when the students take the system development role. The project timeline is an important guide to help students to manage their project. The timeline has been spelt out in a specific manner to help students to clarify the achievable goals set out in each stage. We have also prepared a series of templates to teach students explicit skills in project management, records keeping and user evaluations. Figure 2 shows a template of project initiation record, Figure 3 shows a template of group/team meeting record, and Figure 4 shows sample guidelines on evaluation of the system when the students are in the user role. We have introduced the template of project initiation meeting record to help students to identify individual role in the team and to manage expectation and contribution within the team. This strategy helps to “set the scene” when students meet for the first time.

Although these templates seem to be simple, it is important to provide this type of templates to students. We aim to use these templates as learning scaffolding to provide clear direction to students and to reduce student’s confusion to explain what a student must do to meet expectation and to keep students on task by providing structures and to reduce uncertainty, confusion, frustration and time to eliminate difficulties in embarking on group work in authentic learning situations [6].

In modern work environment, working in group is inevitable. To provide authentic learning experience, team work is indispensable [5]. Collaborations and team work are desired attributes of IS graduates. Industry and employers express desire for IS graduates to have improved skills in individual and group interactions [1]. Collaborations and team work entail communication, cooperation, negotiation, organization, leadership and delegation [4].

One of the problems often cited by students working in group is organising meeting times. To support collaborations and working in virtual space, online discussion space is set up for each team and group in the subject e-learning website. The online discussion space not
only enables students to conduct their meetings and communications in virtual space, beyond time and space boundary, it also functions as project repository. Meeting records, user requirements, system prototypes, comment, feedback and evaluation reports are stored in the discussion space. This provides project memory for all team members and allows sharing of group resources and acts as an inventory for all reports and prototypes.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Meeting</th>
<th>Template and Outcome Documents</th>
<th>By when</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decide/plan</td>
<td>Project initiation meeting</td>
<td>Initiation meeting template</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Follow up meeting, online</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Present key decisions</td>
<td>Submit initiation meeting documents</td>
<td></td>
</tr>
<tr>
<td>Build</td>
<td>Technical specification meeting</td>
<td>Standard meeting template</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Follow up meeting, online</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Present specification meeting</td>
<td>Submit meeting minutes and specification</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Build progress meeting</td>
<td>Standard meeting template</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Finalise draft system meeting</td>
<td>Standard meeting template, submitting draft system for evaluation template</td>
<td></td>
</tr>
<tr>
<td>Evaluate</td>
<td>Evaluation of draft system</td>
<td>Evaluation template</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Follow up meeting, review user evaluation report</td>
<td>Evaluation report</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Revisions progress meeting</td>
<td>Standard meeting template</td>
<td></td>
</tr>
<tr>
<td>Revise</td>
<td>Report meeting, work on project documentation</td>
<td>Report template</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Demonstration of revised system and prepare report submission.</td>
<td>Report</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1: Sample project timeline

The online discussion space also allows the subject coordinator to monitor project progress. Due to the nature of group and team assignment in the assessment, we have taken the following approach in designing online discussion space. Recall that each team consists of two individual students and each group consequently consists of two individual teams. In taking into consideration of private and public information sharing at two levels: team- and group-levels, we have created two discussion spaces for each team: a private team-based discussion space and a public group-based discussion space. The team-based discussion space is only opened to the two team members, whereas the public group-based discussion space is opened for all four team members within the group. This allows intra- and inter-team communications and project repository.

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Meeting date.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>In attendance (names).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Apologies (names).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Key decision 1: Preliminary understanding of user requirements as outlined in the assignment document.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Key decision 2: Preliminary ideas on scope of project and prepare preliminary project plan.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Key decision 3: How you will allocate project tasks. If using Role-based task allocation, list below each role and the name of the person allocated to it. If you are using Modular task allocation list below the name and description of each module and who is responsible for it.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Key decision 4: List below dates, times and locations for remaining face-to-face meetings.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 2: Project initiation meeting record
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Project name.</td>
</tr>
<tr>
<td>2.</td>
<td>Meeting date.</td>
</tr>
<tr>
<td>3.</td>
<td>In attendance (names).</td>
</tr>
<tr>
<td>4.</td>
<td>Apologies (names).</td>
</tr>
<tr>
<td>5.</td>
<td>Status/stage of project.</td>
</tr>
<tr>
<td>6.</td>
<td>Issues discussed.</td>
</tr>
<tr>
<td></td>
<td>- Actions</td>
</tr>
<tr>
<td></td>
<td>- Who will do it?</td>
</tr>
<tr>
<td></td>
<td>- By when?</td>
</tr>
<tr>
<td></td>
<td>- Date done.</td>
</tr>
</tbody>
</table>

**Figure 3: Group/team project meeting record**

<table>
<thead>
<tr>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Has the system developed based on your user requirement?</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>2. Has the system developed based on agreed project plan?</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>3. Do you understand the how the system is used?</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>4. Does the system consistent in design?</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>5. Has the system addressed the requirement you specified in the previous meeting with the system developers.</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>6. What are the strengths of the system at this iteration, and what are its weaknesses?</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>7. Which aspect of the current system you want to improve or enhance?</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>8. What are your expectations of the system in the next iteration?</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Screen design</th>
</tr>
</thead>
<tbody>
<tr>
<td>9. Is the screen uncluttered, clear and easy to follow?</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>10. Do you know where you are at all times, i.e. clear navigation?</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>11. Does the screen provide any help function or error messages to help you to navigate the system?</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Error prevention and correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>12. Does the error message describe what action is necessary?</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>13. Does error occur unnecessarily?</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

**Figure 4: Guidelines on user evaluation**

Authentic learning enables students to reflect on their learning, individually and as a team. Each student is asked to submit a reflective report. It provides an opportunity for students to reflect on the choices they have made in the assessment task as well as outcomes that meet their expectations. Figure 5 shows a template for reflective report.
Sim Kim Lau

1. Briefly describe the aims of your project.
2. Discussion of the system.
3. Describe the difficulties you faced developing this project, and how your team overcame them.
4. Briefly describe the outcomes of the project.
5. Do you think the project was a success? Give your reasons.

Figure 5: Template for reflective report

Students are required to complete a peer-assessment report at the end of the project. The purpose of this report is to provide a mechanism for each team member to evaluate the contribution of the other team member. Another important milestone in the assessment is to have two face-to-face meetings between the groups and the subject coordinator. These meetings are scheduled during the early stages of the project. This is to ensure any problem or conflict the students may encounter in the group can be resolved earlier and to assess work-in-progress.

LESSONS LEARNED

There were twenty students enrolled in the subject, forming five groups. The students have used the templates provided on project timelines, initiation meeting record, project meeting record and guidelines on user evaluation in this subject. Students have provided feedback in the final report that the templates have helped to assist them in planning and managing the project.

As indicated in the precious section, online discussion space has been set up for each group to enable students to communicate as well as serving as a function of project repository. We have found that students have not used the online discussion space as a mean to communicate (except one team has used it regularly as a mean of communication). On the other hand, students had mainly use the space as project repository. Comments from students have indicated that they prefer to use text messages, emails as well as online chat to communicate. In addition, as all students are enrolled in the same class, attending the same lecture and tutorial group, it is not necessary to use the online discussion space as was originally intended. However they have found the space as a project repository is the most useful.

We have found that students have focussed on their role as system developers and not the user role. They have also focussed on system development tasks. The role of the user only becomes dominant during the user evaluation phase. In this case students have not made serious attempts in specifying user requirement when they are asked to take the user role, and they have relied on the broad requirements as outlined in the assignment document.

The strategy of monitoring progress of students by having two face-to-face meetings at the early stage of the semester has been the most useful. To assist students to learn better in a group and to ensure equity in group work contribution, this strategy has helped to resolve distribution of work within the group as well as to manage expectation of team members within the group.

Our teaching evaluation results have indicated marked improvement in the area of “The teacher is well prepared for the subject”, “The teacher simulates me to think”, and “The teacher appears to be interested in assisting me to learn”.

CONCLUSIONS

This paper describes several learning scaffolds that have been developed to assist students to achieve better learning outcome in authentic learning environment. From the teaching perspective, making authentic learning meaningful and achievable is important to help students to work together. Anecdotal evidence from students has showed that the templates have helped them in managing the project. It has also helped students to become aware of the progress they need to make each week. Team working relationships are also easier to manage.

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Sim Kim Lau


STUDENT PERCEPTIONS ABOUT ONLINE CLASSES AND ITS RELATIONSHIP WITH LEARNING, QUALITY AND MOTIVATION

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Parag Dhumal, University of Wisconsin-Parkside, USA, dhumal@uwp.edu

ABSTRACT
This study analyzes student perception about online classes and explores its relationship with learning and quality of online classes. Study further examines the impact of student perceptions on their motivation to take online classes. After analyzing the sample of 162 student respondents to the survey, a scale is developed to measure student perceptions. Results of regression analysis show significant relationship of personal factor, one of factors of developed scale, with learning, quality and motivation to take online classes.

Keywords: Student perceptions, Online classes, Learning, Quality and Motivation

INTRODUCTION
Online courses are becoming the integral part of curriculum in higher education [5]. With the development of information technologies and user friendly applications online courses are becoming popular. Many sources throughout last decade reported sharp increase in online course enrollment in United States [1] [12][13] [17]. Online enrollment has increased from 1.6 millions in fall 2002 to 4.6 millions in fall 2008. A recent survey by Allen and Seaman [1] reported 5.6 million students enrolling for at least one online course during fall 2009. This is an increase of nearly one million students over the number reported the in last year’s survey [2].

Despite predictions of leveling of demand in online education it continues to rise [13]. Not just that online enrollment rates are increasing, it is growing at much higher rate. Compared to two percent overall growth in higher education, online education is growing at 20% that is almost 10 times higher [1]. In fall 2002, online enrollment was 9.6% of total enrollment. In fall 2008 it is 25.3% [12]. More students are taking online courses now. Nearly thirty percent of higher education students are enrolled for at least one course online [1]. This proportion was one in four previous year [2].

This trend of increased demand in online education is observed globally. In fact there is more demand in the foreign countries than capacity [10]. According to Index of E-Learning Market Opportunity developed by Hazel Associates South Korea, Japan, and Germany are ranked as the top three markets in order followed by the UK and China [9]. According to Organization for Economic Cooperation and Development’s Trade in Educational Services 2004 report U.S. is largest exporter of educational services among surveyed eleven countries. There is preference for American Institution degree worldwide and it is estimated that U.S. is educating one third of cross border students [10]. This provide educational institutes great opportunity as well as potential risk if they do not understand the perceptions of students about online classes and its impact on their motivation to enroll for online classes in future.

Our current study is a step forward in this direction. We conduct the survey taking sample of students enrolled in two universities. Goal of this study is twofold. First we study the perceptions of students about online education and then we explore its relationship to learning, quality and motivation of students to take online classes. This paper is structured as follows. In the next section relevant literature is reviewed which is followed by description of survey methodology. Results are described in the next section followed by conclusions and directions for future research.

LITURATURE REVIEW
Online learning is changing the higher education in Unites States. It is more viewed as strategic component. In addition to the universities with mission of distance learning, it is offered by many campus-based universities [6]. Based on survey from the Sloan Consortium and the Babson Survey Research Group, 63% of all reporting institutions said that online learning is a critical part of their institution’s long term strategy [1].

Though more institutions are viewing online learning as strategic component there are concerns perceived by academic leaders in area of support/compensation available and quality and effectiveness of online education. Based on findings of study conducted by Association of Public and Land-Grant Universities and the Sloan National Commission, it was reported that faculties are dissatisfied with support services provided and the incentives offered by public universities [3]. Allen and Seaman [1] reported that 37% of academic leaders rated the learning outcomes in online education as the somewhat inferior or inferior to those in face-to-face. This percentage close to 25% at public institutions compared to 45.6% of private nonprofits and 33.0% of for-profits.
Like academic leaders students have different perceptions [6][16] or sometimes misconceptions about online education [14]. Conducting a longitudinal study, Mortagy and Boghikian-Whitby [15] evaluated student perception in online education in the areas of faculty-student relationship, satisfaction with course activities and student-to-student interaction. Their results show that students enrolling in online classes have high expectations and their perception change over time period. We believe these findings are important. First, it reinforces the importance of analyzing student perceptions and second, it demonstrates that perceptions can be changed if institution takes necessary steps towards improvement. Thus conducting a cross sectional study will help to validate earlier findings and potentially academic institution can use these results for improvements.

Another important reason why student perception should be analyzed is because it may be indicator of future enrollment. Endres et al. [7] found that student satisfaction leads to their intention to recommend course, faculty and university to others. Satisfaction in their research is comprised of five factors, which are dependent on practices that shape students’ experiences or perceptions about online classes. Carr [4] also notes that learning experiences in online classes influences their decision to continue with the course. As more and more students are learning online there is an increasing concern about quality and learning taking place in online classes [8]. In the recent news article in the New York Times front page there are concerns raised about no sufficient research indicating comparable quality of online versus face to face classes at K-12 level [8]. What about higher education? Thus we believe it is necessary to measure what students think about quality and learning in online classes in addition to their motivation to take online classes and further investigate their relationship with student perceptions.

SURVEY

Survey instrument was designed using input from two focus groups and secondary research. Survey was posted online. A pre-notification was sent by email to 600 randomly selected students enrolled at two universities. A fresh email giving the website URL was sent. This process was repeated 5 times with clear instructions not to take the survey if they had previously responded. A further check was made using two criteria: 1) GPA and 2) Computer id. There was no survey found from the same computer id and the same GPA. Instrument consisted of three parts. Part I was demographic information such as gender, student classification, age and enrollment status. Part II consisted of perceptions of lecture versus online classes and type of classes suitable for various business disciplines. Part III addressed their perceptions of online classes with regard to various attributes such as convenience, ease, stress learning amongst others.

STATISTICAL ANALYSIS AND RESULTS

Total 162 students responded to the survey giving a response rate of 27%. This data is entered in SPSS data file to perform statistical analysis. First, demographic characteristics of respondents are analyzed to validate sample is representative of typical college student population. We perform the validity check by measure the correlation between similar questions. Later factor analysis is performed on the 7 items of survey that measures student perception about online classes, to see scale can be developed for online class perception. Two factors are extracted and using summed scale we calculate the score for these factors. Finally regression is performed to see if student perception about online classes is linked to learning, quality and motivation to enroll for online classes in future. In the following subsections results are described in details.

Demographics

Demographic characteristics of individual who completed the survey are given in the Table 1. 54.32% of 162 respondents are male and 43.21% are female. Four respondents have not mentioned gender. Majority of the respondents (83.33%) were between the ages of 18 and 25 years with peaks at 21 years (24.69%). This matches typical traditional college student profile. Further student classification revealed that 6.79% are freshman, 8.64% are sophomore, 22.22% are junior, 50.62% are senior and remaining 11.73% are graduate students. Since majority of students are senior, it explains peak of age profile at 21 years. Almost three quarters of the students were part time, with 17.28% part time and remaining 8.02% not responding to enrollment status. Students are evenly distributed between GPA 3.6 and 4.0, 3.1 and 3.6, and 2.6 and 3.0. There are 12.96% students having GPA 2.5 or less. We believe these sample respondents are representative of typical college student population.

The 11th International DSI and the 16th APDSI Joint Meeting, Taipei, Taiwan, July 12 – 16, 2011, pp.540-546
### TABLE 1: Demographic Characteristics

<table>
<thead>
<tr>
<th>Demographic Variable</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>88</td>
<td>54.32%</td>
</tr>
<tr>
<td>Female</td>
<td>70</td>
<td>43.21%</td>
</tr>
<tr>
<td>Missing</td>
<td>4</td>
<td>2.47%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>162</td>
<td>100.00%</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18 or younger</td>
<td>3</td>
<td>1.85%</td>
</tr>
<tr>
<td>19</td>
<td>9</td>
<td>5.56%</td>
</tr>
<tr>
<td>20</td>
<td>17</td>
<td>10.49%</td>
</tr>
<tr>
<td>21</td>
<td>40</td>
<td>24.69%</td>
</tr>
<tr>
<td>22</td>
<td>33</td>
<td>20.37%</td>
</tr>
<tr>
<td>23</td>
<td>15</td>
<td>9.26%</td>
</tr>
<tr>
<td>24</td>
<td>9</td>
<td>5.56%</td>
</tr>
<tr>
<td>25</td>
<td>9</td>
<td>5.56%</td>
</tr>
<tr>
<td>26 to 35</td>
<td>19</td>
<td>11.73%</td>
</tr>
<tr>
<td>36 to 45</td>
<td>4</td>
<td>2.47%</td>
</tr>
<tr>
<td>45 or older</td>
<td>1</td>
<td>0.62%</td>
</tr>
<tr>
<td>Missing</td>
<td>3</td>
<td>1.85%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>162</td>
<td>100.00%</td>
</tr>
<tr>
<td><strong>Enrollment Status</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part Time</td>
<td>28</td>
<td>17.28%</td>
</tr>
<tr>
<td>Full Time</td>
<td>121</td>
<td>74.69%</td>
</tr>
<tr>
<td>Missing</td>
<td>13</td>
<td>8.02%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>162</td>
<td>100.00%</td>
</tr>
<tr>
<td><strong>Classification</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freshman</td>
<td>11</td>
<td>6.79%</td>
</tr>
<tr>
<td>Sophomore</td>
<td>14</td>
<td>8.64%</td>
</tr>
<tr>
<td>Junior</td>
<td>36</td>
<td>22.22%</td>
</tr>
<tr>
<td>Senior</td>
<td>82</td>
<td>50.62%</td>
</tr>
<tr>
<td>Grad Student</td>
<td>19</td>
<td>11.73%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>162</td>
<td>100.00%</td>
</tr>
<tr>
<td><strong>GPA</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5 or less</td>
<td>21</td>
<td>12.96%</td>
</tr>
<tr>
<td>2.6 to 3.0</td>
<td>45</td>
<td>27.78%</td>
</tr>
<tr>
<td>3.1 to 3.5</td>
<td>49</td>
<td>30.25%</td>
</tr>
<tr>
<td>3.6 to 4.0</td>
<td>47</td>
<td>29.01%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>162</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

### Validity Check

In order to perform validity check similar questions are included in survey and then correlation between them is calculated. For example, the respondents are asked to rate if they felt online classes are less stressful than lecture classes and later they are asked to rate level of agreement with sentence online classes are stressful. Results shows spearman’s rho = -0.495 and correlation is significant at 0.01 significance level. Similarly spearman’s rho is 0.292 (significant at level is 0.01) between survey items online classes are convenient and one of the advantages of taking course online is the fact that class times were flexible. Significant correlation validates

### Scale Development: Student’s perceptions about Online Classes

Student’s perception about online classes is measured using 7 items in the survey. These items are on-line classes
are: Stressful, Difficult, Useful, Complex, Convenient, Suits my learning style and easy to complete. Students are asked to indicate their level of agreement or disagreement with the above statements on a five point scale. Factor analysis is performed to identify which of the 7 items would cluster together distinctively and to determine the number of dimensions or factors underlying the construct –Student’s perceptions about online classes. The item easy to complete is dropped due to loadings on multiple factor. Factor analysis using varimax rotation on remaining 6 items extracted 2 factors with eigenvalues greater than 1.00. Both these factors accounted for 62.346% of the variance explained. The factor contents, rotated factor loadings, eigenvalues, variance explained and cumulative variance explained are given in Table 2. The first factor is named as personal factor which comprised of items online classes are useful, convenient and suits my learning style. Second factor is named as complex factor which consists of items online classes are stressful, difficult and complex. The score for the each factor is calculated by taking simple average of the underlying item scores.

### TABLE 2: Factor Analysis for Student’s Perception about Online Classes

<table>
<thead>
<tr>
<th>Rotated Component Matrix</th>
<th>Factor 1</th>
<th>Factor 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Personal Factor</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Online Classes are - Useful</td>
<td>0.821</td>
<td></td>
</tr>
<tr>
<td>Online Classes are - Convenient</td>
<td>0.813</td>
<td></td>
</tr>
<tr>
<td>Online Classes are - Suits my learning style</td>
<td>0.71</td>
<td></td>
</tr>
<tr>
<td><strong>Complex Factor</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Online Classes are - Stressful</td>
<td></td>
<td>0.762</td>
</tr>
<tr>
<td>Online Classes are - Difficult</td>
<td></td>
<td>0.847</td>
</tr>
<tr>
<td>Online Classes are - Complex</td>
<td></td>
<td>0.64</td>
</tr>
<tr>
<td><strong>Eigenvalue</strong></td>
<td>2.27</td>
<td>1.48</td>
</tr>
<tr>
<td><strong>Proportion Variance Explained</strong></td>
<td>32.73%</td>
<td>29.62%</td>
</tr>
<tr>
<td><strong>Cumulative Variance Explained</strong></td>
<td>32.73%</td>
<td>62.35%</td>
</tr>
</tbody>
</table>

**Student’s Perceptions and Learning**

Factor analysis results suggest that student’s perception about online classes consist of two factors—personal factor and complex factor. One of goal of the study is to find out if there is relationship between student’s perceptions about online classes and learning. Learning is measured by asking students how much they have learned in online classes compared to face to face class. Options given are more, same and less. Regression is preformed using learning as dependent variable and personal factor and complex factor as independent variables. Overall regression model is found to be significant but complex factor is not. Regression is preformed eliminating complex factor variable and model is found to be significant (p value 0.000). Personal factor explains 12.9% of variance observed in the learning. Regression results are given in Table 3.

### TABLE 3: Regression Results for Learning as Dependent Variable and Personal Factor as Predictor Variable

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>1.389</td>
<td>7.563</td>
<td>.000</td>
</tr>
<tr>
<td>Personal Factor</td>
<td>.343</td>
<td>4.504</td>
<td>.000</td>
</tr>
</tbody>
</table>

Model significance = 0.000; Adjusted $R^2 = 0.129$

Learning = $B_0 + B_1 \times \text{Personal Factor}$

Learning is measured as $1 = \text{more}, 2 = \text{equal}$ and $3 = \text{less}$
Student’s Perceptions and Quality

To find out if there is relationship between student’s perceptions about online classes and quality regression is performed using quality as dependent variable and personal factor and complex factor as independent variables. Quality is measured by asking respondents if Quality of online classes compared to face to face is better or equal or worse. Regression result shows that complex factor is not a significant predictor of quality. After eliminating complex factor regression is performed and model is found to be significant (p value 0.000) with personal factor explaining 13.8% of variance observed in quality. Result of this regression is given in Table 4.

Student’s Perceptions and Motivation

To analyze impact of student’s perceptions about online classes and their motivation to take online classes regression is performed using motivation as dependent variable and personal factor and complex factor as independent variables. Motivation is measured by asking respondents When it comes to an online classes how motivated are you. Options given are I would not take a course online, I would consider taking a course online and I would like to take a course online. Like to above two cases complex factor is not found to be a significant predictor of motivation. After eliminating complex factor regression is performed and model is found to be significant (p value 0.000) with personal factor explaining 31.5% of variance observed in motivation. Result of this regression is given in Table 5.

### Table 4: Regression Results for Quality as Dependent Variable and Personal Factor as Predictor Variable

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Std. Error</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td></td>
<td>3.697</td>
<td>.222</td>
<td>16.680</td>
</tr>
<tr>
<td>Personal Factor</td>
<td></td>
<td>.461</td>
<td>.089</td>
<td>5.182</td>
</tr>
</tbody>
</table>

Model significance = 0.000; Adjusted $R^2 = 0.138$

Quality = $B_0 + B_1 * Personal Factor$

Quality is measured as 1 = better, 2 = equal and 3 = worse

### Table 5: Regression Results for Motivation as Dependent Variable and Personal Factor as Predictor

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Std. Error</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td></td>
<td>3.296</td>
<td>.156</td>
<td>21.076</td>
</tr>
<tr>
<td>Personal Factor</td>
<td></td>
<td>-.544</td>
<td>.063</td>
<td>-8.663</td>
</tr>
</tbody>
</table>

Model significance = 0.000; Adjusted $R^2 = 0.315$

Motivation = $B_0 + B_1 * Personal Factor$

Motivation is measured as 1= I would not take a course online, 2 = I would consider taking a course online and 3 =I would like to take a course online.
CONCLUSIONS AND FUTURE RESEARCH

This study investigates student’s perception about online classes. From factor analysis results we found two dimensions of perception, personal factor and complex factor. Personal factor comprise of online classes are useful, convenient and suits my learning style where as complex factor comprise of online classes are difficult, complex and stressful. These perceptions, we believe, are based on their experience with online classes and will determine students’ motivation to take online classes in future. Regression result showed significant relationship of only personal factor with motivation of students to take online classes with 31.5% of variance explained. These results are important and provide guidance to academic institutions that are seeking to increase online enrollment. Focus on personal factor is the key for institutions to improve online classes. This means, first, find what students expect and what makes classes useful in their opinion. Second, what tools, features, technology and/or provisions in course makes it convenient. And lastly, investigating different learning styles and providing multiple options for students to learn. May be institution should encourage students to take test to determine their learning style and further guide them to choose classes and study accordingly. These results could also be used in the development of online courses. Institution should further look into using learning theory in designing the survey and outcome of the course. In addition they should also evaluate helpfulness of technology used for delivering online courses. As pervious research pointed out, technology can help us to eliminate barriers to learning [11]. Focusing on personal factor would not only help institution to increase enrollment but will further help to improve quality and learning that in the online classes as regression results show significant relationship with learning and quality. This study also validates the finding of previous studies in online education related to learning, quality and motivation. Thus it makes important contribution to theory and practice.

This research opens new avenues for further research. As pointed out earlier, further research is warranted in the area of investigating different learning styles, what delivery methods are suitable for different learners and how technology will be useful in this matter.

REFERENCES


* Dates are in MM/DD/YYYY format
INCORPORATING DATA MINING INTO COURSE EVALUATION: 
A CASE STUDY OF K-12 VIRTUAL SCHOOL

Jui-Long Hung, Southwestern University of Finance and Economics, algaandy@gmail.com 
Qingcheng Gao, Southwestern University of Finance and Economics, gaoqingcheng@gmail.com

ABSTRACT
This study aimed to propose a new approach of course evaluation through analyses of student learning logs and demographic data in order to support reflections on teaching and learning at the K-12 level. A case study was conducted with a total of 7,539 students (23,854,527 learning logs in 883 courses). Clustering analysis was applied to construct student profiles. Findings include (a) female students performed better than male students in most subject areas. (b) Students younger than 16.6-year-old performed better older students. (c) Student geographic location is not an important factor for academic success.

Keywords: Educational Data Mining; Course Evaluation; K-12 Virtual School

INTRODUCTION
The flexibility, convenience, just-in-time availability and personalized learning opportunities available in online courses have fueled exponential growth in US K-12 online programs and schools. Although exact numbers are difficult to obtain, a survey of school district administrators found that more than a million US K–12 students took online courses in the 2007-08 school year [1]. Other reports predict 1.4 million children will be taking online courses in cyber-charter schools by 2014 [2]. However, a 2010 report from the International Association for Online Learning (iNACOL) indicates that this number has already been surpassed with an estimated 1.5 million US K-12 students enrolled in online programs [3]. We also know state-led virtual schools and online learning initiatives account for almost half a million enrollments in 39 states—a near 40% increase over the previous year. Full time virtual schools continue growing in number: currently 27 states with an estimated 200,000 students. Although difficult to track, an estimated 50% of US K-12 school districts across the country have online or blended program in place [4], [5], in their book “Disrupting Class,” estimate that by the year 2019, 50% of all US high school courses will be online.

Traditionally, instructors and institutional administrators rely on course evaluation surveys to evaluate course effectiveness and generate information for decision making. Lacking direct observation opportunities, and aiming to provide more customized learning experiences, online instructors need effective tools, other than course evaluations, to track students’ online learning activities and to improve student outcomes through personalizing instruction, identifying struggling students, adjusting teaching strategies, and improving course design. Institutional administrators need to track students’ online learning activities in order to effectively oversee courses, depict students’ general learning characteristics, study trends across courses or years, and implement institutional strategies for improved student outcomes. Each of these needs can be addressed by incorporating data mining into student evaluation.

PURPOSE OF THIS STUDY
The purpose of this study aimed to propose a new approach of course evaluation through analyses of student learning logs and demographic data in order to support reflections on teaching and learning at the K-12 level. The new approach

RELATED WORK
Educational data mining
Data mining (DM) is a series of data analysis techniques applied to extract hidden knowledge from server log data [6] by performing two major tasks: pattern discovery and predictive modeling [7].

Related techniques have been widely used in business fields, especially in e-commerce, for providing personalized business services [8], identifying potential customers [9], adjusting marketing strategies [10, pp. 1189-1220], improving website design [11], and more. Modern online education relies heavily on learning management systems (LMS) or course management systems (CMS). These LMS/CMS automatically record navigational behavior of individual users as server logs. Therefore, data mining techniques can also be applied to solve issues of online teaching and learning.

However, Educational Data Mining (EDM) is faced with special challenges due to the dynamic characteristics of e-learning in five aspects:

1. Behaviors: Learning behaviors are complex, including different types of interactions (student-content, student-student, student-instructor, etc.) and varied sequences of learning interactions [12][13][14, pp. 41-56].

The 11th International DSI and the 16th APDSI Joint Meeting, Taipei, Taiwan, July 12 – 16, 2011, pp.547-553
2. Target variables: The most common target variable in e-commerce studies is buying or not buying. In e-learning studies, however, a common target variable is learning outcomes or performance [15], which requires a rather wide range of varying assessments and indicators.

3. Goals: The major goal of data mining in e-commerce is to increase profit, which is tangible and can be measured quantitatively. On the other hand, the major goal of data mining in e-learning is to improve online teaching and learning, which might be difficult to measure or quantify [16].

4. Techniques: With different behaviors, target variables, and goals, only specific data mining techniques are suitable for analyzing educational questions [16]. In addition, data for educational data mining need different modifications from e-commerce studies.

5. Data collection: Only interactions which occurred in LMS/CMS can be tracked. However, a great deal of learning might occur outside the LMS.

Although EDM, in comparison with commercial data mining applications, has the above constraints, external variables such as demographic information and survey investigation are more easily collected at educational institutions than from commercial websites. Those possibilities provide great potential in EDM, especially for result interpretation and evaluation.

**METHOD**

**Data source**

Data were collected from a statewide K-12 supplemental online institution that serves over 16,000 students virtually in a northwestern state of the US including three types of data: 1) LMS activity logs and 2) student demographic data. The online K-12 institution serves an important need in a state that is primarily rural, providing course offerings to students in resource-poor school districts who would otherwise not have access. It also serves the state by providing online professional development training to teachers. Their courses, delivered using the Blackboard LMS, provide a rich source of data from a diverse student and teacher population across a broad region.

**LMS activity logs**

The sources for data mining were the LMS (Blackboard) activity logs for the duration of Fall 2009 to Spring 2010. A total of 23,854,527 activity logs were collected from 7,539 students in 883 courses.

**Demographic data**

The following demographic data were collected for data analysis: age, gender, graduation year, city, school district, number of online course taken, number of online course passed, number of online course failed, and final grade average.

**Analytic tools**

SAS (Institute Inc., Cary, NC, USA) Enterprise Miner 6.1 was employed to perform the following data mining tasks in this study: 1) Learner profiling: describe shared characteristics of students who passed or failed the course. 2) Perception and performance predictions: identify key predictors to predict course satisfaction, instruction satisfaction, and final grade.

**RESULTS**

Table 1 lists variables collected from Blackboard and student management database. Some variables were transformed by calculation in order to generate more meaningful variables for analysis. For example, student’s birth year was transformed to age. The summary of all learning activities was aggregated to a new variable called “frequency of clicks.” It represents each student’s total frequency of clicks on the Blackboard Learning Management System. If students took more than one course during the analysis period, variables of learning activities (e.g. frequency of total clicks and frequency of course access) and performance (e.g. final grade) were averaged.

**TABLE 1 Variables for data mining**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>stuID</td>
<td>Student’s ID</td>
</tr>
<tr>
<td>Age</td>
<td>Student’s age</td>
</tr>
<tr>
<td>City</td>
<td>Student’s residential city</td>
</tr>
<tr>
<td>District</td>
<td>Student’s school district</td>
</tr>
<tr>
<td>Grade_Avg</td>
<td>Average course grade</td>
</tr>
<tr>
<td>Click_Avg</td>
<td>Average frequency of click/course</td>
</tr>
<tr>
<td>Content_Access_Avg</td>
<td>Average frequency of course accessed/course</td>
</tr>
<tr>
<td>Course_Access_Avg</td>
<td>Average frequency of course accessed/course</td>
</tr>
<tr>
<td>Page_Access_Avg</td>
<td>Average frequency of page accessed/course</td>
</tr>
<tr>
<td>DB_Entry_Avg</td>
<td>Average number of discussion board entries/course</td>
</tr>
<tr>
<td>Tab_Access_Avg</td>
<td>Average frequency of tab accessed/course</td>
</tr>
<tr>
<td>Login_Avg</td>
<td>Average frequency of logins/course</td>
</tr>
<tr>
<td>Module_Avg</td>
<td>Average frequency of module accessed/course</td>
</tr>
<tr>
<td>Gender</td>
<td>Gender</td>
</tr>
<tr>
<td>HSGradYear</td>
<td>High school graduation year</td>
</tr>
</tbody>
</table>
Online learning interactions

Engagement is thought to be a key variable for enabling and encouraging learners to interact with the material, with the instructor, and with one another, as well as for learning generally [17]. In this study, engagement level was measured by frequency of various learning interactions happened in the Learning Management System.

Clustering analysis

Clustering analysis was applied to group students based on their shared characteristics. A pass rate equals to 1 means a student passed all courses during the period of analysis. Pass rate equals to zero means a student failed all courses during the period of analysis. Pass rate between 0 and 1 means a student passed partial courses during the period of analysis. In this study, pass rate was set up as the standard for classification and 6 clusters were generated after clustering analysis.

Table 2 shows results of clustering analysis in academic year 2009/10. Below are shared characteristics of each cluster.

Cluster 1 (316 students, pass rate 55.07%, all males): Cluster 1 consists of students who are older than clusters 3-6. They were lower-engaged students than Clusters 5 and 6 but higher than Clusters 3 and 4. On average, each student took 2.76 courses and failed around half of them.

Cluster 2 (320 students, pass rate 56.11%, all females): Similar to Cluster 1, Cluster 2 consists of students who are older than clusters 3-6. They are lower-engaged than clusters 5 and 6 but higher than Clusters 3 and 4. On average, each student took 3.03 courses and failed around half of the courses.

Cluster 3 (594 students, pass rate 0%, all males): Clusters 3 and 4 include lowest-engaged students. Cluster 3 students are all male. On average, each student took 1.43 courses and failed all of them.

Cluster 4 (601 students, pass rate 0%, all females): Cluster 4 includes lowest-engaged female students. On average, each student took 1.39 courses and failed all of them.

Cluster 5 (2,311 students, pass rate 100%, all males): Clusters 5 and 6 represent highest-engaged students.

Cluster 5 students are all male. On average, each student took 1.59 courses and passed all of them.

Cluster 6 (3,397 students, pass rate 100%, all females): Cluster 6 represents highest-engaged female students who passed all their courses. On average, each student took 1.64 courses.

TABLE 2 Clustering analyses in the academic year 2009/10

<table>
<thead>
<tr>
<th>Clusters</th>
<th>CL1</th>
<th>CL2</th>
<th>CL3</th>
<th>CL4</th>
<th>CL5</th>
<th>CL6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Students</td>
<td>316</td>
<td>320</td>
<td>594</td>
<td>601</td>
<td>2311</td>
<td>3397</td>
</tr>
<tr>
<td>Pass rate =0</td>
<td>316</td>
<td>320</td>
<td>594</td>
<td>601</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pass rate (&lt;0 and &gt;1)</td>
<td>316</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Gender</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3397</td>
</tr>
<tr>
<td>GenderF</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3397</td>
</tr>
<tr>
<td>GenderM</td>
<td>316</td>
<td>0</td>
<td>594</td>
<td>0</td>
<td>2311</td>
<td>0</td>
</tr>
<tr>
<td>Age</td>
<td>16.9</td>
<td>17.1</td>
<td>16.7</td>
<td>16.8</td>
<td>16.6</td>
<td>16.59</td>
</tr>
<tr>
<td>Grade_Avg</td>
<td>50.1</td>
<td>52.8</td>
<td>22.4</td>
<td>20.9</td>
<td>81.75</td>
<td>85.4</td>
</tr>
<tr>
<td>Click_Avg</td>
<td>583</td>
<td>549</td>
<td>440</td>
<td>416</td>
<td>892.5</td>
<td>881.7</td>
</tr>
<tr>
<td>Content_Access_Avg</td>
<td>113</td>
<td>112</td>
<td>93.8</td>
<td>89.4</td>
<td>180.3</td>
<td>178</td>
</tr>
<tr>
<td>Course_Access_Avg</td>
<td>170</td>
<td>172</td>
<td>134</td>
<td>142</td>
<td>281.5</td>
<td>284.2</td>
</tr>
<tr>
<td>DB_Entry_Avg</td>
<td>4.08</td>
<td>5.28</td>
<td>2.78</td>
<td>4.22</td>
<td>8.28</td>
<td>9.57</td>
</tr>
<tr>
<td>Login_Avg</td>
<td>29.4</td>
<td>24.4</td>
<td>23.6</td>
<td>19.2</td>
<td>47.92</td>
<td>46.42</td>
</tr>
<tr>
<td>Module_Access_Avg</td>
<td>156</td>
<td>145</td>
<td>113</td>
<td>102</td>
<td>249.2</td>
<td>240.8</td>
</tr>
<tr>
<td>Page_Access_Avg</td>
<td>99.6</td>
<td>89.4</td>
<td>72</td>
<td>62.5</td>
<td>145.4</td>
<td>142.4</td>
</tr>
<tr>
<td>Tab_Access_Avg</td>
<td>41.9</td>
<td>37.8</td>
<td>30</td>
<td>26</td>
<td>62.04</td>
<td>60.72</td>
</tr>
<tr>
<td>No_Fail</td>
<td>1.23</td>
<td>1.33</td>
<td>1.43</td>
<td>1.39</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No_Pass</td>
<td>1.52</td>
<td>1.7</td>
<td>0</td>
<td>1.59</td>
<td>1.64</td>
<td>1.64</td>
</tr>
<tr>
<td>No_course</td>
<td>2.76</td>
<td>3.03</td>
<td>1.43</td>
<td>1.39</td>
<td>1.59</td>
<td>1.64</td>
</tr>
</tbody>
</table>

Geographical distributions

The clusters generated from cluster analysis were associated with one geographical variable (school) to reveal geographic distribution of each cluster. Figure 1 shows clustering distributions by city for the whole academic year of 2009/10.

Figure 1 reveals that clusters 1 to 4 consist of similar geographical distributions. The results indicate student failure in online courses was not limited to specific areas or cities. However, many successful male students are from one larger city at Northwestern. On the other hand, many successful female students are from the other two larger cities.

FIGURE 1 Cluster Geographical Distributions of the whole 2009 Academic Year
Cluster 1 (316 students, pass rate 55.07%, all males)

Cluster 2 (320 students, pass rate 56.11%, all females)

Cluster 3 (594 students, pass rate 0%, all males)

Cluster 4 (601 students, pass rate 0%, all females)

Cluster 5 (2,311 students, pass rate = 100%, all males)

Cluster 6 (3,397 students, pass rate = 100%, all females)
Subject areas

Table 4 shows students’ average frequencies of total clicks and performances per course in different subject areas. Total clicks are equal to the summarized frequency of overall learning activities. Table 4 shows that Math and Science have the highest number of total clicks per course and of total clicks per student per course. However, the average of students’ final grades (56.70 and 64.41 accordingly) are lower than overall average (71.11). The results indicate students participated actively in courses of these two subject areas; however, they failed to achieve expected outcomes. Therefore, it is necessary to examine course designs and teaching strategies in these two subject areas.

On the other hand, teachers in English courses need to motivate students’ participation because the low final grade might result from low engagement level. Students in Foreign Language and Health not only participated in learning activities actively but also obtained highest grades in each of these two subject areas.

TABLE 4 Average engagement levels and performances in different subject areas

<table>
<thead>
<tr>
<th>Subject Areas</th>
<th>Total Clicks</th>
<th>Total Clicks/student</th>
<th>No of Students</th>
<th>Final Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drivers Ed</td>
<td>4808</td>
<td>227.97</td>
<td>21.09</td>
<td>78.4</td>
</tr>
<tr>
<td>Electives</td>
<td>5353.63</td>
<td>247.69</td>
<td>21.61</td>
<td>76.59</td>
</tr>
<tr>
<td>English</td>
<td>4807.79</td>
<td>239.98</td>
<td>20.05</td>
<td>62.09</td>
</tr>
<tr>
<td>Foreign Language</td>
<td>7824.63</td>
<td>439.4</td>
<td>17.81</td>
<td>76.54</td>
</tr>
<tr>
<td>Health</td>
<td>6641.8</td>
<td>269.99</td>
<td>24.6</td>
<td>83.58</td>
</tr>
<tr>
<td>Math</td>
<td>7898.35</td>
<td>444.05</td>
<td>17.79</td>
<td>56.7</td>
</tr>
<tr>
<td>Science</td>
<td>9015.16</td>
<td>603.53</td>
<td>14.94</td>
<td>64.41</td>
</tr>
<tr>
<td>Social Studies</td>
<td>4740.92</td>
<td>245.97</td>
<td>20.09</td>
<td>70.58</td>
</tr>
<tr>
<td>Average</td>
<td>6386.29</td>
<td>323.43</td>
<td>19.75</td>
<td>71.11</td>
</tr>
</tbody>
</table>

Subject preferences

Figure 2 shows percentages of female and male students in different subject areas. Subject preferences of male and female students are revealed by comparing gender percentages of each subject with the overall percentages. The results indicate female students prefer to take Electives, Foreign Language, and Social Science. Male students prefer to take Drivers Education, Math and Science.

FIGURE 2 Gender distribution in different subject areas

Pass rate in different subject areas

Table 5 consists of two parts. The first part examines whether pass rates of female and male students in different subjects have significant differences. Table 5 lists subject pass rates of female and male students. “F vs M” compares gender pass rate difference using t-tests. The second part examines pass rate difference between Fall 2009 and Spring 2010 within the same gender. For example, “F vs F” compares pass rate difference between Fall 2009 and Spring 2010 female students in different subjects by using t-tests. Numbers marked with asterisks represent differences have statistical significance.

TABLE 5 Pass rate differences of female and male students in different subject areas

<table>
<thead>
<tr>
<th>Terms</th>
<th>Fall 2009</th>
<th>Spring 2010</th>
<th>Fall 2009 vs. Spring 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>F M F vs M</td>
<td>F M F vs M</td>
<td>F vs M M vs M</td>
</tr>
<tr>
<td>Drivers Ed</td>
<td>0.91 0.89 0.623</td>
<td>0.96 0.86 0.044*</td>
<td>0.156 0.779</td>
</tr>
<tr>
<td>Electives</td>
<td>0.85 0.79 0.000*</td>
<td>0.91 0.87 0.000*</td>
<td>0.025* 0.015*</td>
</tr>
<tr>
<td>English</td>
<td>0.69 0.57 0.000*</td>
<td>0.83 0.72 0.000*</td>
<td>0.000* 0.000*</td>
</tr>
<tr>
<td>Foreign Language</td>
<td>0.83 0.8 0.088</td>
<td>0.91 0.89 0.121</td>
<td>0.006* 0.036*</td>
</tr>
<tr>
<td>Health</td>
<td>0.92 0.9 0.023*</td>
<td>0.97 0.97 0.058</td>
<td>0.067 0.084</td>
</tr>
<tr>
<td>Math</td>
<td>0.55 0.54 0.769</td>
<td>0.72 0.7 0.761</td>
<td>0.000* 0.000*</td>
</tr>
<tr>
<td>Science</td>
<td>0.71 0.67 0.233</td>
<td>0.85 0.81 0.418</td>
<td>0.000* 0.000*</td>
</tr>
<tr>
<td>Social Studies</td>
<td>0.78 0.74 0.000*</td>
<td>0.89 0.84 0.000*</td>
<td>0.000* 0.000*</td>
</tr>
<tr>
<td>Overall</td>
<td>0.24 0.31 0.000*</td>
<td>0.13 0.2 0.000*</td>
<td>0.000* 0.000*</td>
</tr>
</tbody>
</table>

Based on the results of Table 5, female significant performed better than male students, especially in the following subject areas: Electives, English, and Social Science.

In addition, Spring 2010 pass rate is significant higher than Fall 2009, especially in those subjects with lower pass rate such as English, Math, Science, and Social Science.

Summary of findings

Findings below were summarized by combining results from the academic year of 2009/10 and from Spring 2010 only.
1. Students with higher engagement level usually have higher performance. In addition, these students usually have twice as many of all learning activities as low-engaged students.

2. Optimal course number is 1 to 2 per semester.

3. Low-engaged students (who failed in all courses) were about 15.9% on average per course. High-engaged students (who passed in all courses) were about 75.7% students on average. Mid-engaged students (who passed partial courses) were about 8.4 on average per course.

4. Students who were younger than 16.6-year-old had higher pass rate than students who were older than 16.6-year-old. In addition, older students tended to take more than two courses with around 54.09-56.11% pass rates. Therefore, further facilitations should be in place for students who are older than 16.6 and take more than one course.

5. Female students had higher pass rates and final grades than male students, especially in the following subject areas: Electives, English, and Social Science. In addition, Female students were more active than male students in online discussion (with higher DB_Entry avg frequency).

6. In this study, graphical location is not an important factor for academic success because failure in online courses was not limited to specific areas or cities. However, gender plays an interesting role in successful students because many successful male students are from one larger city and many successful female students are from the other two larger cities.

7. Female students preferred to take Electives, Foreign Language, and Social Science and male students preferred to take Drivers Education, Math and Science. Students in Math and Science had the lowest pass rates in all subject areas with the highest average engagement levels. The results indicated the course design in these two subject areas should be re-examined. On the other hand, students in in English courses need to be motivated in order to increase their engagement level for cultivating successful students.

8. Overall, students in Spring 2010 semester performed significantly better than those in Fall 2009 because interventions implemented in Spring 2010.

CONCLUSION

This study has made the following contributions: 1) It explored potential applications at the K-12 level for educational data mining that has already been broadly adopted in higher education institutions. 2) It proposed a new course evaluation approach by combining student learning logs with demographic data to generate in-depth knowledge for decision making. 3) The case study identified profiles of potential at-risk students. The finding can be adopted by the K-12 online institutions to create an intervention system (or early alarm system) to help these students being successful.

REFERENCES


IMPROVING SMALL BUSINESS ENTERPRISE MANAGEMENT AND STUDENT INTEREST IN ENTREPRENEURSHIP THROUGH STUDENT-INVOLVED LEARNING IN INDONESIA

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Shao-Chi Chang, National Cheng Kung University, Taiwan

ABSTRACT

Despite SMEs’ resilience with regard to the economic crisis, their contribution to the Indonesian economy is still very small. Even though many ideas have been offered to improve the performance of SMEs, the SMEs themselves have a lot of constraints preventing implementation, such as limitations with regard to their human resource capacities. The purpose of this paper is to present a learning design offering business students a chance to implement the theories they get in the classroom to the real business world as well as improving their interest in entrepreneurship, while at the same time giving small business enterprises an opportunity to have their problems investigated, discussed and resolved.

Keywords: small business enterprises, education, student, entrepreneurship, practical experience.

INTRODUCTION

When an economic crisis hit Asia in 1997, Indonesia suffered severely. The Indonesian rupiah depreciated in excess of 70 percent, which resulted in the collapse of many enterprises, most of which were large corporations with high foreign debt exposure. This situation raised unemployment, a result of which was social unrest and large demonstrations that successfully forced the late president Soeharto to step down after 32 years in power.

What happened to corporations, however, had only a small impact on small and medium-sized enterprises (SMEs). This was because they had little or no foreign debt in their portfolios, which prevented them from experiencing currency fluctuations. In addition, most of them also relied on domestic sources and markets for their products.

Despite SMEs’ resilience with regard to the economic crisis, their contribution to the Indonesian economy is still very small. The latest data shows that 96.2 million people work at 52.8 million small and medium scale companies, while only 2.7 million people work at 4,677 big corporations. However, those huge numbers of SMEs, along with their workforces, contribute only 56.5 percent to the national economy. [19]

The small contribution of SMEs to the Indonesian economy stem from the fact that SMEs are still faced with many traditional problems, namely lack of financing (around half of SMEs are not bankable), difficulties with exploiting technology, constrained managerial capabilities, low productivity, as well as regulatory burdens, which become more acute in a globalized and technology-driven environment. Most of the human resources in SMEs are also not well-educated people. These weaknesses of SMEs are found not only in developing countries, but are also found in developed countries, as described by an OECD (Organization for Economic Co-operation and Development) report. [22]

When compared with medium-sized enterprises, small-sized enterprises seem to have poorer management.

In the context of Indonesia, this situation meets its importance when the huge numbers of SMEs and the current practice of teaching in most business schools are taken into consideration.

RESEARCH ON SMEs

Many researchers have been trying to identify general methods by which to improve SME performance. Some researchers have focused on various aspects of human resource management as a way to enhance the quality of SMEs [12][14][27], while the others have investigated how SMEs can take benefits from strategic alliances and partnerships [8][9][13][16], the ways good financial management can contribute to SMEs performance [18][32], risk management practice and ideas in SMEs [3][6][30], implementation of knowledge management [5][29], roles of financial and managerial accountancy for SMEs [20][23], as well as strategic management in SMEs [7][21].

Even though many ideas have been offered to improve the performance of SMEs, the SMEs themselves have a lot of constraints preventing implementation, such as limitations with regard to their human resource capacities. In this context, universities can play a significant role. However, so far only a small amount of research has paid attention to the contribution universities may give to SMEs. [2][10][31]

CURRENT PRACTICE OF TEACHING AND CONDITION OF SMEs

Current teaching practice in business schools at undergraduate level in Indonesia is conducted mostly in one-way model. When studying financial accounting, cost accounting, managerial accounting, financial management, production management, marketing management, human resource management, risk management, and the like, students are usually treated just the same as they would be if they were studying literature, for example. In the class, instructors of business classes describe the theory of the courses in front of the students, ask the students to do quizzes and give them exams in the middle and end of each semester. In financial accounting classes, for example, the students never even see a real financial statement, balance sheet, ledger, or any other financial transaction forms, even though they are well versed in performing accounting transactions and in producing various accounting reports. Similar situations also exist in other such classes, where students have a high knowledge base but lack practical experience.
On the other hand, SMEs lack qualified human resources. More than half of them only graduate from elementary schools, while the other quarter is junior high school graduates. Most of them even do not know how to make transaction records let alone produce financial reports that are very important in running their businesses, in their decision-making processes and in improving the quality of their businesses.

In Indonesia, in addition to small-scale and medium-scale enterprises, there is third category called micro-sized business enterprises. Indonesian Law on Micro-, Small-, and Medium-scale enterprises [25] distinguishes amongst those three categories of enterprises from their total assets and annual sales.

An enterprise is categorized as micro-sized enterprise if its total assets excluding land and building less than Rp (Indonesian Rupiah) 50,000,000 (US$ 5,747) and annual sales not more than Rp 300,000,000 (US$ 34,482). Meanwhile, a company is classified as small-scale enterprise when its total assets more than Rp 50,000,000 but less than Rp 500,000,000 (US$ 57,471) and annual sales in the range of Rp 300,000,000-Rp 2,500,000,000 (US$ 287,356). Lastly, an enterprise will be categorized as medium-sized company if it has total assets more than Rp 500,000,000 but less than Rp 10,000,000,000 (US$ 1,149,425) and annual sales between Rp 2,500,000,000-Rp 50,000,000,000 (US$ 5,747,126).

In terms of financing, there is a group called the “productive poor” which includes poor small farmers, micro-entrepreneurs, and poor sectors of the rural population including women and youths, and the like. “Productive poor” means that person are poor but they are working to generate income for themselves, either through being self-employed or forming a partnership or a group, being a part of an association trying to generate income for themselves [33].

Unfortunately, a survey reveals that 70% of productive poor in Indonesia still see banking institutions as specter because of procedural complexity, collateral needs, and the like. They just consider banks as not for them [15].

**PURPOSE OF THE PAPER**

The purpose of this paper is to present a learning design offering business students a chance to implement the theories they get in the classroom to the real business world, while at the same time giving small business enterprises an opportunity to have their problems investigated, discussed and resolved.

This paper emphasizes that students with practical experience will have a better understanding of the courses they attend, and proposes a design to further develop and advance some previous researches. [10][31] This paper also suggests the mixture of business students of various specializations in order to get better and more comprehensive understanding of the wide aspects of problems of small business enterprises. In addition, this paper also describes the importance of this learning arrangement as the way to develop student interest in entrepreneurship. This purpose is getting strategically important in current circumstances where society often consider that being a civil servant or an employee of a large company is more prestigious than being an entrepreneur.

**THE ARRANGEMENT OF THE PROGRAM**

Instead of focusing on medium-sized enterprises, this paper pays more attention to small-sized business enterprises (SBE) for two reasons. First, SBEs need more assistance to improve the quality of their management, which is worse when compared with medium-sized enterprises, and thus, SBEs also offer more problems that can be addressed by students. Second, SBEs are likely more eager to offer opportunities to students to get involved in their businesses.

We can also widen the targets by including micro-sized enterprises as long as they meet criteria in providing students sufficient business problems to be learnt in terms of size and complexity.

This learning model proposes students as groups of consultants for small business enterprises. Unlike Dumouchel [10] that allows a student acts as an individual consultant and assumes any single student knows every problems faced by the SME, in this arrangement students are grouped into small groups of no more than 10 students, and each group is assigned to a specific small business enterprise. We suggest that each group consists of students from different specializations in order to give a more comprehensive understanding of the problems of the SBEs.

The Schools first issue the guidelines of the program, describing every step need to know and obey by students. During the first week of semester, every group of students needs to search the SBEs around their campus that willing to accept the students to “work” and provide enough problems to be investigated and resolved simultaneously. A contract then needs to be signed by each party as the guidelines.

During the semester, the students are asked to routinely visit and oversee small business enterprises assigned to their groups and learn how those companies operate and run their businesses. This visit can be arranged once every one or two weeks. Accounting students, for example, can assist enterprises with accounting transaction records, producing financial statements, balance sheets and other reports, while students of other specialty areas can discuss ways to overcome the problems companies face in the areas of functional management such as finance, marketing, and operations as well as those areas involving human resources and the future development of the enterprises.

While the program is running, faculty members assigned to supervise this program regularly visit the SBEs to see whether there are any problems or any other obstacles need to be overcome. They will also take notes to be discussed with the students when they report their work in the last week of the semester.

In the last week of the semester, every group of students will have to report their work, including the condition of the SBE, problems experience by the firm, actions taken to resolve the problems, as well as plans of business development in the future.
The assessment of the students will be based on the combination of students’ activities during the program, reports, presentation, and assessments from the owners/managers of the SBEs. Dumouchel [10] suggests sources for evaluation along with their percentage: student journal (15%); participation: peer support and feedback (10%); report 1: client project proposal (10%); client contract (5%); report 2: interim report—progress to date and literature review (15%); report 3: final write-up of deliverables including major projects (25%); in class presentation of final report and consulting experience (10%); and client assessment of student performance, motivation and attitude (10%).

There are two sources of funding to implement this program. The first source, of course, is from the university itself. Secondly, we can expect corporate social responsibility fund from large corporations which operate around the university or community.

The economic crisis and reformation era have brought up a new spirit of transparency, democracy, and social awareness. Initiated by multinational companies, now, more and more companies operating in Indonesia are adopting corporate social responsibility because they believe it is the right thing to do. However, its implementation is not always easy due to some external factors affecting business [17].

Corporate social responsibility is a voluntary principle, but government is tempted to impose regulation that would force business to comply with corporate social responsibility principles. In 2007 Government of Indonesia enacted Indonesian Law on Corporations that stipulates obligation for every corporation that its operation related with natural resources to implement social and environmental corporate responsibility. This responsibility should be formally budgeted and reported as corporation’s operational cost and will be punished for disregarding this obligation [24].

Many companies in Indonesia (local and international) have proved corporate social responsibility as a business case, or that being socially responsible is good for their business. Being socially responsible can help business to build business sales, quality and reliable workforce, as well as build trust in the company as a whole [17].

Even though there is still question on the effectiveness of this corporate social and environmental responsibility program, corporations generally obey this obligation. These companies usually grant 1-5% of their profit to fulfill their obligation to community. Many of them also have good commitment to education and will likely be willing to participate in the program of student involvement in the business entities. By allocating the corporate social and environmental responsibility fund to finance the program of student-involvement in small-scale business enterprises will also increase the effectiveness and usefulness of the fund’s spending. Corporations can choose to allocate their funds to university and community that have strong linkage with their business.

**BENEFITS OF THE PROGRAM**

This teaching arrangement offers mutualistic symbiosis among the students, universities, and small business enterprises. By participating in this arrangement, students have opportunities to implement the knowledge they have already acquired in the classroom. Participating in the day-to-day business of enterprises also enhances their practical understanding of the courses they are taking.

Having students with a higher level of understanding will also benefit universities since the students will enter the job market with better skills and a higher level of confidence and will also be better prepared for real world situations.

Small business enterprises, of course, will also benefit from “recruiting” a fresh group of consultants. Since they have weaknesses in wide aspects of their management, they will have opportunities to discuss these weaknesses with students who have been equipped with state-of-the art knowledge of management and business.

One more party that will also benefit from this student-involved learning activity is the nation, as a result of having an opportunity to have more entrepreneurs in the future. As previous scholars have found, entrepreneurship is important factors in the economic development of a nation. [1][4] However, according to the latest statistics, the ratio of entrepreneurs to the general population is only 0.24% of 238 million in the Indonesian population. This figure is far below the ratio of entrepreneurs to the population in the United States (11%), Japan (10%), Singapore (7%), or Malaysia (5%). Therefore, in line with previous researchers’ findings as [11][26][28] we believe that the opportunity for students to be involved in the business activities of small business enterprises is more likely to increase the interest of the younger generation to become entrepreneurs in the future.

This program also provides corporations with useful and effective way to allocate their funds of corporate social and environmental responsibility as required by Law.

**CONCLUSION**

The current practice of teaching in most Indonesian business schools is conducted in traditional way, which is in the classroom without giving enough opportunity to the students to feel the real world of business.

By giving opportunity to the business students to interact with the real business practices and problems, students will have a better understanding of the courses they are taking. Meanwhile, SBEs will take benefits from having opportunities to get their problems discussed and resolved.

In addition, through this program arrangement student interest in entrepreneurship and their intentions on entrepreneurial career choice in the future is likely to increase.
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EXCEPTIONAL ELEMENTS FRAMEWORK IN GROUP TECHNOLOGY

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ABSTRACT

The concept of Cellular Manufacturing Systems has become very popular in the 1990’s. Recently, the CMS has been considered an integral part of the lean manufacturing systems. The CMS incorporates Group Technology (GT) principles. The basic idea of GT is to utilize the similarity between parts and manufacturing processes. Parts similar in design and manufacture are grouped into part families. Machines are organized into machine cells to process part families. This grouping process is termed as the Cell Formation (CF). Unfortunately, the grouping is not always possible to ensure that all parts of a family can be processed within a machine-cell. The CF process tends to inherit exceptional element problems that can create difficulty in achieving manufacturing benefits and efficiencies. In this research, a concise review of the current state of existing methods that can best be used in eliminating the exceptional elements is conducted. An evaluative framework is presented to discuss the usefulness and limitations of the current existing methods.

Keywords: Cell Formation, Group Technology, Exceptional Elements, Cellular Manufacturing Systems, Lean Manufacturing Systems

INTRODUCTION

The Cellular Manufacturing Systems (CMS) has been considered an integral part of the lean manufacturing systems. It is a manufacturing system that incorporates Group Technology (GT) principles [1]. Group Technology has been proposed to increase productivity in manufacturing. The basic idea of GT is to offer a system approach to the reorganization of the traditional functional batch manufacturing systems such as the job-shop and flow shop to more flexible small-lot production. The CMS is a production system that will allow a set of dissimilar machines to be grouped into a machine cell to process a group of product/part family. A product/part family is a group of parts that can be produced by the same sequence of machining operations because of similarity in design and processing attributes. This will allow the systems to exploit the similarity between parts and manufacturing processes.

The main objective of the CMS is to achieve benefits and efficiencies in manufacturing. The benefits and efficiencies of CMS include work-in-process (WIP) reduction, lead-time or throughput time reduction, productivity improvement, quality improvement, better scheduling, simplicity in tool control, enhanced flexibility and visibility, and better teamwork and communication. The benefits of applying CMS have been extensively discussed in [2].

The Group Technology principles require the ability to classify parts into part families and form machines into machine cells which are dedicated to the manufacture of a specific part family. Unfortunately, the grouping is not always possible to ensure that all parts of a family can be processed within a machine-cell and tend to create the problem of the bottleneck machines and parts issues in the CF effort. The purpose of this research is to present the current state of existing methods in use that deal with the exceptional element problems in GT. The approaches and their effectiveness of these solution methods are discussed and presented in a framework.

BACKGROUND

Most of the grouping methods employ M x P machine-part incidence matrix (see Figure 1) to group machine-cells and part families.

![Figure 1: Machine-Part Incidence Matrix](image)

The incidence matrix is a matrix that describes the machines requirements to process each part type. The matrix consists of binary entries of blanks or ‘1’s’, in which an entry of ‘1’ indicates that machine i is used to process part j, i = 1, 2…6 and j = 1, 2…8. When an initial machine-part incidence matrix is constructed such as shown in Figure 1, each machine-cell that is dedicated to manufacture of a specific part family is not visible. However, when a leading methodology is employed, machine-cell and its part family can be identified (see Figure 2).

Figure 2 shows the formation of machine cells (MC) and part families (PF) after the grouping process. It shows not all members of a part family can be processed within a single machine cell. The members having operations in more than one machine-cell are called bottleneck parts and the machines processing them are known as bottleneck machines. For instance, Part Type 1 in Figure 2 is a bottleneck part. Part Type 1 has to transfer to Machine Cell-2 (MC-2) and Machine Cell 3 (MC-3) for processing after going through processing in Machine Cell-1 (MC-1) due to its exceptional elements (2,1) and (4,1). The machine #2 in MC-2 is a bottleneck
eliminate the handling of exceptional elements after the cell formation grouping process. Chow and Hawaleshka [21] proposed a more effective algorithm, which reduced the number of bottleneck parts compared with the average clustering algorithm Seifoddini and Wolfe [8] and linear cell clustering algorithm of Wei and Kern [22]. The other researchers that had developed algorithm to reduce the appearance of the bottleneck parts and machines include Chan and Milner [23], King & Nakornchai [24], Kern & Wei [25], Tsai, Chu, and Barta [26], and Won [27]. The grouping algorithms that were developed by these researchers can only reduce the existence of bottleneck parts, but the bottleneck parts could still be present.

Vannelli and Kumar [28] proposed to eliminate bottleneck parts through bottleneck machines duplication and subcontracting bottleneck parts. They proposed to duplicate bottleneck machines irrespective of the machine cost and cell size constraint and requirement. This model purports to solve the exceptional element problem by duplication bottleneck machine cells that possess the largest number of inter cellular moves and continues duplication until no machine generates more intercellular moves than specified by a threshold value. Seifoddini [29] presented a cost-based duplication procedure, which uses the duplication cost and the associated reduction in intercellular material handling cost as a basis for decision making in the duplication process. The bottleneck machine is duplicated if the duplication cost is less than the associated cost reduction in intercellular material handling. Seifoddini [29] encouraged duplication in the process until duplication no longer can be economically justified. This duplication method cannot eliminate bottleneck parts problems once the duplication process is not economically justified. Ang [30] developed an algorithm for eliminating bottleneck parts that minimizes total duplication costs for the entire system and its duplication process. Ang’s method only assumed bottleneck machines duplication is the only viable method to use to eliminate bottleneck parts. The method is not practical since in the real world, bottleneck machines duplication should not be considered as the only method used to eliminate the bottleneck parts problems. Moreover, the duplication cost, which includes the machine purchasing cost, machine maintenance cost and depreciation, is usually very high.

The subcontracting is an alternative for bottleneck parts and machines elimination which is raised by Kusiak and Chow [31]. Kusiak and Chow [31] proposed subcontracting bottleneck parts if bottleneck part production cost due to intercellular movements is greater than subcontracting cost. Kamien and Li [32] also proposed the important aspect in capacity planning, and it implies that the producer can establish a long-term supplier-producer relationship for parts in long-term planning so that purchasing the exceptional parts is possible. However, if in a specific environment, subcontracting cost is greater than production cost, the offending bottleneck part will not be subcontracted and the bottleneck parts problem remains unsolved.

Another alternative approach purporting to solve the exceptional element problem in group technology is the
The mathematical programming method has also been developed to handle the existence of bottleneck parts and machines in Group Technology. Shafer, Kern, and Wei [35] used mathematical programming to resolve bottleneck machines and parts problems. The programming resolved the problems through improving cell configuration and optimization by comparing the process of bottleneck machines duplication and subcontracting bottleneck parts. Shafer and Rogers [36] present a goal-programming approach to cell formation in which bottleneck machines and parts can be handled by equipment purchases or allowing the intercellular movements to remain. Gunasingh and Lashkari [37] employ a cost-based integer programming approach to allow for both machine duplication and the possibility of having some intercellular movements remain. The majority of these mathematical programming models developed to handle the existence of bottleneck parts and machines explicitly considered three cost categories: (1) subcontracting costs; (2) machine duplication costs; and (3) intercellular transfer costs. If the practical environments object the use of subcontracting, duplication, and intercellular movements, the bottleneck machines and parts remained unsolved.

Cheng, Goh, and Lee [38] used heuristic branching rule to settle the bottleneck machines and parts problem after the grouping cell process. Unfortunately, the heuristic branching rule can only reduce the number of bottleneck parts, but it cannot eliminate the existence of bottleneck parts completely. Hachicha, Masmoudi, and Haddar [18] used a simulation-based methodology to form cell and handle the bottleneck parts and machines with cost effective measures of either through allowing intercellular transfer or duplication of bottleneck machines. The handling of bottleneck problems is resolved through the duplication and subcontracting through simulation only. If cell size, financial constraint, and proprietary pattern and technology secret do not permit resolving the exceptional elements either through duplication or subcontracting, the bottleneck problems remained unsolved in the cell formation process.

CONCLUSIONS

The purpose of this research is to present the current state of existing, well-documented methods in use that can resolve the bottleneck parts and machines problem in group technology. An evaluative framework of exceptional elements problems is summarized in Table 1 in which the methods of handling the exceptional elements and the method effectiveness are discussed and presented.

| Table 1: Summary of Solution Methods to Handling of Exceptional Elements (EE) |
|---------------------------------|----------------|----------------|
| Method and Contributors | Method Effectiveness | EE Universally Solved? |
| **Algorithms** | | |
| 1. Chow et al. [21] | More effective cell formation algorithms that can result in less exceptional element existence in the final grouping cell formation process. | No |
| 2. Seifoddini et al. [8] | | |
| 3. Wei and Kern [22] | | |
| 4. Chan et al. [23] | | |
| 5. King et al [24] | | |
| 7. Tsai et al. [26] | | |
| 8. Won [27] | | |
| **Bottleneck Machine Duplication** | | |
| 1. Vannelli et al. [28] | Duplicate Bottleneck Machines irrespective of their machine costs to configure machine-cells that can be dedicated to process the part-family. | No |
| 2. Ang [30] | | |
| **Cost Based Bottleneck Machine Duplication** | | |
| 1. Seifoddini [29] | The bottleneck machine is duplicated if the duplication cost is less than the associated cost reduction in intercellular material handling. | No |

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<table>
<thead>
<tr>
<th>Method and Contributors</th>
<th>Method Effectiveness</th>
<th>EE Universally Solved?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Algorithm Bottleneck Machine Duplication</strong></td>
<td>An algorithm for eliminating bottleneck parts that minimizes total duplication costs for the entire cellular manufacturing systems. This algorithm assumed machines duplication is the only viable method to eliminate bottleneck parts.</td>
<td>No</td>
</tr>
<tr>
<td>1. Ang [30]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Subcontracting</strong></td>
<td>Subcontract bottleneck parts if production cost due to intercellular movements is greater than the subcontracting cost. However, if subcontracting cost is greater than production cost, the offending bottleneck part will not be subcontracted and the bottleneck parts problem remains unsolved.</td>
<td>No</td>
</tr>
<tr>
<td>1. Kusiak and Chow [31] 2. Kamien and Li [32]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Method and Contributors</th>
<th>Method Effectiveness</th>
<th>EE Universally Solved?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Proc. Plan Modification</strong></td>
<td>In a case in which parts cannot be grouped into a family, the process plan for bottleneck parts could be modified so that they can be processed in existing machine-cells. Regardless, the intercellular movement is avoidable to transport modified bottleneck parts to the exclusive machine-cell to be processed.</td>
<td>No</td>
</tr>
<tr>
<td>1. Wemmerlove et al. [33] 2. Kusiak [34] 3. Shafer et al. [35]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mathematical Programming</strong></td>
<td>The programming resolved the problems through improving cell configuration and optimization by comparing the process of bottleneck machines duplication and subcontracting bottleneck parts. EE remains if production environments do not allow machine duplication or subcontracting, the problem remains.</td>
<td>No</td>
</tr>
</tbody>
</table>
This research also confirmed that the exceptional element problem in group technology has the following features:

1. Methods for handling bottleneck machines and parts problems involve both quantitative and qualitative approaches. Efficiency among the methods varies and there are no complete and universally satisfactory methods to date that can eliminate bottleneck parts problems in the cellular manufacturing systems. For instance, the exceptional element problems may be addressed by using an algorithm, a qualitative approach, or a combination of several algorithms and approaches.

2. To date, it seems difficult, if not impossible, to eliminate completely exceptional elements in a production environment in order to avoid intercellular movement. For example, exceptional elements will remain when the duplication machine costs are greater than the intercellular movement handling costs.

3. These methods have benefits and offer to make the production environment a more efficient, more profitable arena. There is no one unique solution formulation capable of handling all exceptional element problems.

It is important to resolve the exceptional element problem in GT so that a complete cell formation solution in group technology can be achieved to offer a more efficient and productive cellular manufacturing systems.

### REFERENCES


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### Table 1: Summary of Solution Methods to Handling of Exceptional Elements (EE) Cont’

<table>
<thead>
<tr>
<th>Method and Contributors</th>
<th>Method Effectiveness</th>
<th>EE Universally Solved?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heuristic Rules</td>
<td>1. Cheng et al. [38]</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>The heuristic branching rule can only reduce the number of bottleneck parts, but it cannot eliminate bottleneck parts completely.</td>
<td></td>
</tr>
<tr>
<td>Simulation</td>
<td>1. Hachicha et al. [18]</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>The handling of bottleneck problems is resolved through the duplication and subcontracting through simulation only. The EE problem remains if production environments do not support duplication and subcontracting.</td>
<td></td>
</tr>
</tbody>
</table>


TOWARDS AN INTEGRATED FRAMEWORK FOR THE ADOPTION OF PROCESS MANAGEMENT PRACTICES

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ABSTRACT

This study sheds light on the organizational adoption motives of process management practices. The recent theoretical explanation that the institutional environment plays a major role in influencing the adoption may have underestimated the importance of management’s personal initiative and downplayed the role of organizational resources. Using data from 330 manufacturers, the study shows that management pro-activeness and technical concentration exert stronger influence on the adoption than the institutional pressure does. It also reveals that management pro-activeness is the most versatile motive among others. Furthermore, the three motives are driving different adoption patterns that have not been explored in the literature before.

Keywords: process management, institutional pressure, knowledge-based view, management pro-activeness, technical concentration

INTRODUCTION

Perspective based on institutional theory has been drawing research attention in explaining the adoption of quality management, e.g., [12][47][83] and supply chain management systems, e.g., [11][53][69]. This study, in an attempt to extend this line of research, aims at establishing a more comprehensive theoretical model to explain and predict the organizational adoption of process management practices. We argue that the influence of institutional environment is not sufficient to explain and predict the decision of process management adoption.

As strategic management researchers, e.g., [17][58][59][65][78] have increasingly recognized the insufficiency of explaining organizational behaviors solely from the institutional perspective, they advocate the importance of assessing the relative potency of institutional and economically driven explanations of organizational phenomenon. In fact, the recent surge of studies in OM has substantiated such view that the adoption of operations practices and systems such as those related to supply chain integration [11], internet-enabled supply chain system [53], and supplier development program [69], are not solely influenced by institutional environment but by multiple coexisted environments. This is in congruent with the view of some researchers that organizations adopting process management practices are competing in multiple, but paradoxical, environments [9][75].

In a spirit of extending research efforts on the institutional perspective to the OM arena and in an effort to deepen our understanding of the dynamics of process management adoption, we consider the adoption of process management practices is under the influence of three coexisted antecedents: institutional pressures, management pro-activeness and technical concentration.

THEORETICAL BACKGROUND AND HYPOTHESES

The categories of process management practices

Process management traces its roots to the paradigm shift initiated by quality movement advocated by the early gurus, e.g., [20][44]. It inspired the rethinking of organizational structure, that organizations should not be perceived as a hotpot of separate functions, but rather as a set of interlinked processes [19][67]. The importance of process management lies in its indispensable role in realizing the principles of quality management, i.e., predictability and reliability. As a matter of fact, it is the core component in many quality management frameworks, e.g., Malcolm Baldridge Award Criteria and ISO9000. In this study, we focus on two process management practices: incremental process improvement and radical process improvement.

Incremental process improvement

Incremental process improvement refers to a set of management practices aiming at enhancing existing processes continuously at a small pace and scale. It is based on the perception that each process can change locally and gradually [56]. Therefore, it is characterized by its achievements: process stability and small wins [13][14][43][54][68]. In addition, it is inseparable from its continuous nature [4]. Processes can be continuously improved because organizations are naturally and continuously adapting to their changing environments and internal situations [26][50][82]. This kind of process improvement is characterized by a slow pace and small scale of improvements [32]. In other words, it is an ongoing activity targeting at escalating organizational performance through focused incremental changes in processes [2][6].

Radical process improvement

Radical process improvement refers to a set of management practices aiming at building new processes at a large pace and scale [32]. In contrast to incremental process improvement, radical process improvement is based on the perception that processes should covary to maintain performance [56].

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Because of the interlinked processes, any improvement should be concerted and dramatic [56]. Grounded in radical organizational change theory, radical process improvement views process change as radical and dramatic [21][25][34][51][56][70]. It is divergent in nature, with a revolutionary implementation pace and scale [32]. Radical process improvement disrupts existing activity patterns and builds new order and references [30]. To be dramatic, fundamental rethinking and the redesign of processes is necessary [37][48]. Therefore, it challenges the status quo [74] and strategically transforms interrelated organizational systems [49].

Inter-relationships among the process management practices

From the perspective of organizational learning, the small wins in incremental process improvement help to build up the momentum for radical process improvement [14] and to maintain the effect of the radical change [48][50]. The literature has showed that the small wins trigger radical process improvement by promoting learning and accumulating problem solving knowledge and capabilities [13][75][64] such that both work efficiency and employee proficiency can be achieved. The accumulation of employee proficiency elicits radical change [13]. As [43, p.19] note “continuous [incremental] change has a role to play in maximizing the likelihood of success in more capital-intensive radical improvement, through work simplification before implementing new technology.” In light of the above perspectives, we hypothesize the following:

H1: the adoption of incremental process improvement positively influences the adoption of radical process improvement.

Institutional pressures

Different from the perspective based on quality management that the adoption of process management practices is basically efficiency-driven in order to pursue economic performance, e.g., [9][20][27], the perspective based on neo-institutional theory [22][23][55][52][60][73] has been widely touted as its suggestion that the adoption is largely legitimacy-driven so as to fulfill social expectation and sustain survival. The adoption hence is a passive attempt to obtain societal resources through conforming to pressures from the institutional environment. Organizations doing so will be perceived by society as not only more worthy, but also as more meaningful, more predictable, and more trustworthy [72].

The seminal work of [22] in neo-institutional theory revealed three major institutional pressures that force organizations toward institutionalization. First, coercive pressure stems from the coercive power exercised by the resource holders. This pressure, which all organizations face, traces its roots to resource dependence theory [62][63] which states that more dependent an organization is on the resource holder, higher the propensity of the focal organization to do whatever the resource holder expects. Second, mimetic pressure results from responses to market uncertainty. This pressure originates from the fact that organizations tend to imitate what the industry best performers are doing, particularly, when the environment is highly uncertain [22]. Finally, normative pressure originates from commonly accepted norms in the industry. When norms of best practices and values have been established in an industry, organizations tend to comply with them because these norms become judgment criteria for their legitimacy in the industry [55][84].

These three institutional pressures drive organizations to adopt process management practices for the sake of legitimacy. It is because the stakeholders favor reliable organizational performance and this results in the avoidance of fundamental change that could potentially disrupt the organization’s reliability and increase its probability of failure [38][46]. According to this perspective, organizations will avoid fundamental change, adhering to their stakeholders’ expectations, which results in convergent change to their status [32]. When managers implement process management practices at the request of their customers, to avoid the risk of failure, organizations play it safe by focusing on incremental process improvement. Thus, we hypothesize the following:

H2: Institutional pressure positively influences the adoption of incremental process improvement.
H3: Institutional pressure positively influences the adoption of radical process improvement.
H4: Institutional pressure imposes stronger influence on the adoption of incremental process improvement than on that of radical process improvement.

Management pro-activeness

The criticality of employees’ personal initiative in the adoption and performance of process management practices has seldom been addressed in the literature. In this study, we focus on one aspect of managers’ personal initiative, pro-activeness, which is critical to the adoption of process management practices. Proactive managers will pay more attention to their organization’s stakeholders, including customers and suppliers [41]. These managers are more willing to improve the relevant processes so as to adapt to various stakeholders’ needs. In fact, considering management pro-activeness as a driver of the adoption of process management practices implies that managers, as decision makers, will actively choose the extent of their implementation. This is in contrast to reactively responding to what other organizations in the industry are doing, represented by the neo-institutional perspective.

Pro-activeness is one of the key dimensions of the strategic orientation of business enterprises [80]. Pro-activeness is defined as the “continuous search for market opportunities and experimentation with potential responses to changing environmental trends (Miles & Snow 1978)” [80, p.949]. Proactive managers seek “new opportunities, which may or may not be related to the present operations, introduction of new products and brands ahead of competition, strategically eliminating operations which are in the mature
or declining stages of life cycle.” [80, p. 494]. Pro-activeness is consistent with [39] Stage IV on organization development roadmap, which is typical of world class organizations. Stage IV organizations actively seek to anticipate the potential of new manufacturing practices and technologies; in some cases, these new practices will not be related to a current need, but are pursued to help to position the organization to meet unknown future challenges. Thus, long-range programs are pursued to develop capabilities in advance of actual needs. Thus, [39]’s perspective which consents the role of pro-activeness, is in sharp contrast with the institutional perspective.

To this end, we conjecture that management pro-activeness will affect the adoption of process improvement practices directly, in two ways. First, more proactive managers will be more likely to seek radical process improvement because of their propensity to challenge the status quo, explore new challenges, search for new opportunities and venture into unfamiliar situations. Proactive managers are more visionary and anticipate the emergence of crises much earlier than their competitors, thus, they are well prepared for radical process improvement and the associated outcomes. Second, [7] contends that proactive managers actively create environmental change, actively seeking information and opportunities for improving things. They recognize the long-term value of incremental process improvement to their organization; they will induce more changes to the organizations, frequently proposing alternatives to improve the current situation. Therefore, there will be more incremental change that occurs. In addition, proactive managers will persistently provide improvement direction and cultivate an environment conducive to incremental process improvement. Since these managers are more long-term oriented and scan various environments more frequently, they will spare more time for change. Thus, the need for radical change will be less than that for incremental change. Hence, we come up with the follows:

H5: Management pro-activeness positively influences the adoption of incremental process improvement.
H6: Management pro-activeness positively influences the adoption of radical process improvement.
H7: Management pro-activeness imposes stronger influence on the adoption of incremental process improvement than on that of radical process improvement.

Technical concentration

According to the knowledge-based view (a special application of the resource-based view), the knowledge possessed by an organization is one of the valuable, rare, inimitable and non-substitutable resources by which the organization can achieve a competitive advantage [5][24][28][43]. This is particularly true for technical knowledge. In the organizational change literature [18][21][25][33][34], technical knowledge is operationalized as technical concentration, i.e., the number of technical specialists in an organization. This literature also suggests that the higher the technical concentration that an organization has, the higher its propensity to generate “Green House Effect” that increases the propensity of radical process improvement. Innovative ideas will be more likely, due to the interaction among the aggregated technical experts [21]

Although technical concentration is typically associated with radical process improvement [18], it does not necessarily imply that technical concentration is not essential for incremental process improvement activities. A higher technical concentration may triggers more incremental process improvement projects; the experience of the technical experts can support more process improvement projects by providing guidance in determining improvement directions and transferring the necessary technical knowledge to the project teams. Nevertheless, due to the “Green House Effect”, the expected improvement will be more likely be radical than incremental. We propose:

H8: Technical concentration positively influences the adoption of incremental process improvement
H9: Technical concentration positively influences the adoption of radical process improvement
H10: Technical concentration imposes stronger influence on the adoption of radical process improvement than that of incremental process improvement.

The hypothesized model is shown in Figure 1.

![Hypothesized Model](image)

**Figure 1 Hypothesized Model**

**Independent Variables**

**Institutional pressure.** As government and customers are the common sources of coercive pressure because of their role as resource holders [22], two measurement items were developed respectively to probe the informants’ rating on how important government’s and customers’ concern on whether or not the company was implementing effective improvement practices. For mimetic pressure, according to [22], the source will most likely be the environmental uncertainty which triggers companies to mimic their best performers or competitors in the industry. To this end, one item was established to probe informants’ response about the extent of importance of understanding competitors’ way of improvement. Last, normative pressure originates from the...
norm widely adopted in industry. One item was thus used to ask informants to express the degree of importance of information exchange in the industry about the approach of improvement.

**Management Pro-activeness.** We select and modify items suggested by [7] related to personal pro-activeness. Based on the three-sample’s factor loadings provided by the authors, we calculate the average factor loadings of each item and then select items with the threshold greater or equal to 0.55 [36]. We next determined the most related items by referencing to [80] and [16]. As a result, six items were selected.

**Technical concentration.** Even though the literature has defined and operationalized technical concentration as the number of technical specialists in an organization, such measure is however, not without limitation. Due to the samples of different background to be studied, counting the number of technical specialists may be a biased measure. It is because the same number of technical people perceived by one company as adequate may be regarded as insufficient in another company. To this end, we newly develop measurement items based on literature focusing on the perceived adequacy of the number of technical people. From the OM literature [40], we identify the technical knowledge that is important to process improvement in manufacturing industry. It includes knowledge related to production technology, statistical analysis, problem solving tools and process analyst. Thus four items were established.

**Dependent Variable**

**Incremental Process Improvement.** Previous studies adopting empirical measures specifically addressing the incremental process improvement is scarce. To this end, we identify the measurement items for the incremental process improvement based on the literature that is basically conceptual work. Specifically, items were identified to reflect the extent of continuous nature of incremental process improvement, the involvement of front-line employees, the tactics used to simplify the existing processes, so and so forth. After consulting several academic and industrial experts, five items are retained for EFA.

**Radical Process Improvement.** Similar to the status of incremental process improvement, seldom can we find empirical studies using validated items to measure radical process improvement. In this connection, we review the literature and developed nine measurement items to measure radical process improvement. After consulting academic and industrial experts, six items were retained for EFA.

**Control Variable**

**Organizational Size.** Organizational size is related to practice adoption behavior because of the higher degree of centralization and formalization in larger organizations. In such organizations, more resources are available for the implementation of manufacturing programs, therefore, larger plants may be more successful adopting process management practices than smaller plants. In this study, organizational size is operationalized as the number of employees [71]. The natural logarithm of the number of employees was used [76], in order to account for the diminishing effect of organization size [10][85].

**RESEARCH METHODOLOGY**

**Questionnaire design and measures**

We designed a questionnaire with a six-point Likert scale [8][35][66] to avoid a tendency toward neutral responses, with “1” denoting “strongly disagree” and “6” denoting “strongly agree.” Note that this scale has no neutral midpoint. Senior operations managers from eight different manufacturing organizations were invited to pretest a refined Chinese questionnaire. Face-to-face and phone interviews were conducted to clarify the questionnaire items and obtain suggestions for their modification.

**Sampling and data collection**

The questionnaire was administered to senior production managers in the selected data pool. The unit of analysis is individual plants. Our target organizations were Hong Kong manufacturing organizations with plants in the Pearl River Delta region of China. Industries related to electronics, plastics, rubber, metal, textiles and garments were selected. The questionnaire, a cover letter explaining the purpose and administration of the questionnaire, and a self-addressed stamped envelope were then mailed to the senior production manager of each organization in our targeted population. Ultimately, there were 330 usable questionnaires, yielding a response rate of approximately 10.0%. The demographics of the sample are shown in Table 1.

We estimate non-response bias [36], using t-tests to determine if differences existed in demographic characteristics, including organizational size and last year’s average sales revenue [45]. Results show that the two groups are statistically the same, with regard to size and sales revenue.

**Table 1 Sample Demographics**

<table>
<thead>
<tr>
<th>Industries</th>
<th>No. of companies</th>
<th>Average Organizational Size (No. of Employees)</th>
<th>Last Year’s Average Sales Revenue (in Millions of USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical and Electronics</td>
<td>81</td>
<td>1150</td>
<td>35.7</td>
</tr>
<tr>
<td>Plastics and Rubber</td>
<td>94</td>
<td>578</td>
<td>8.9</td>
</tr>
<tr>
<td>Apparel</td>
<td>43</td>
<td>713</td>
<td>16.2</td>
</tr>
<tr>
<td>Machine and equipment</td>
<td>8</td>
<td>315</td>
<td>5.6</td>
</tr>
<tr>
<td>Chemical</td>
<td>6</td>
<td>493</td>
<td>15.8</td>
</tr>
<tr>
<td>Textiles</td>
<td>33</td>
<td>2347</td>
<td>39.2</td>
</tr>
<tr>
<td>Metal</td>
<td>35</td>
<td>589</td>
<td>9.3</td>
</tr>
<tr>
<td>Toys</td>
<td>16</td>
<td>1617</td>
<td>19.8</td>
</tr>
<tr>
<td>Printing</td>
<td>7</td>
<td>320</td>
<td>4.6</td>
</tr>
<tr>
<td>Plastic + Metal</td>
<td>7</td>
<td>436</td>
<td>8.1</td>
</tr>
<tr>
<td>Total</td>
<td>330</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Measurement instrument quality

The sample was randomly split into a calibration sample and a validation sample. We randomly drew 100 cases to develop the calibration sample for scale construction and purification, which included tests for unidimensionality and reliability using exploratory factor analysis (EFA) [36][84]. The remaining 230 cases were then examined for validation purposes, using confirmatory factor analysis (CFA).

Unidimensionality. The measurement items were subjected to EFA on a subscale-by-subscale basis. Items of which the largest factor loading was greater than or equal to 0.60 and of which the cross-loading difference is larger or equal to 0.10, were retained [57]. In addition, the percentage of variance of the measurement items extracted by the construct should be greater than 50%, or its eigenvalue should be much larger than 1.0 [36]. To obtain a more reliable factor analysis result, we aggregate items of incremental process improvement and radical process improvement. The results of EFA as shown in Table 2 reveal that the resultant items all possess satisfactory factor loading strength.

As shown in Table 2, items of all constructs fulfill the set criteria. The five items of incremental process improvement display dual factors. While the first one comprising three items concerns about the improvement strategy, the second with two items addresses the improvement tactics. Among the six items of radical process improvement, two items were eliminated due to significant cross-loading problem. For the institutional pressure, all four items load on one single factor. Among the six items used for management pro-activeness, two items were found having relatively weak factor loadings and therefore removed from the scale. The four remaining measurement items load on one single construct with factor loading. Finally, the four items of technical concentration also load on one single construct.

### Table 2. EFA Results (n=100) [# denotes reverse code item]

<table>
<thead>
<tr>
<th>Items</th>
<th>Factor Loadings</th>
<th>Cronbach’s alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A Incremental Process Improvement Strategy</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Eigenvalue=1.80 % of variance explained =60.12)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 We run process improvement projects on a continuous basis</td>
<td>0.82</td>
<td>0.65</td>
</tr>
<tr>
<td>2 We encourage front-line employees to participate in process improvement</td>
<td>0.88</td>
<td></td>
</tr>
<tr>
<td>3 We implement process improvement in a gradual way.</td>
<td>0.58</td>
<td></td>
</tr>
<tr>
<td><strong>B Incremental Process Improvement Tactics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Eigenvalue=1.39 % of variance explained =69.61)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 We seek ways to simplify existing processes.</td>
<td>0.83</td>
<td>0.56</td>
</tr>
<tr>
<td>2 We continuously reduce process variation, even if it is already at an acceptable level.</td>
<td>0.83</td>
<td></td>
</tr>
<tr>
<td><strong>C Radical Process Improvement</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Eigenvalue=2.33 % of variance explained=58.16)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 We design a totally new process.</td>
<td>0.85</td>
<td>0.76</td>
</tr>
<tr>
<td>2 We use IT as an enabler in process redesign.</td>
<td>0.76</td>
<td></td>
</tr>
<tr>
<td>3 Senior management encourages “thinking out of the box”</td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td>4 We implement radically the newly designed process</td>
<td>0.74</td>
<td></td>
</tr>
<tr>
<td><strong>D Institutional Pressure</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Eigenvalue=2.71 % of variance explained=54.32)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Customers’ concern about whether we are implementing process</td>
<td>0.80</td>
<td>0.71</td>
</tr>
<tr>
<td>2 Our understanding of how competitors implement process improvement</td>
<td>0.73</td>
<td></td>
</tr>
<tr>
<td>3 Government’s concern about whether we implement process improvement</td>
<td>0.56</td>
<td></td>
</tr>
<tr>
<td>4 Information exchange about how processes are improved in the industry</td>
<td>0.82</td>
<td></td>
</tr>
<tr>
<td><strong>E Managerial Pro-activeness</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Eigenvalue=2.63 % of variance explained=65.63)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Senior management seldom explore new operating philosophy and strategy*</td>
<td>0.78</td>
<td>0.83</td>
</tr>
<tr>
<td>2 Senior management always challenge the status quo of operations*</td>
<td>0.82</td>
<td></td>
</tr>
<tr>
<td>3 Senior management can spot a good opportunity long before others</td>
<td>0.82</td>
<td></td>
</tr>
<tr>
<td>4 Senior management are not powerful enough for constructive change*</td>
<td>0.82</td>
<td></td>
</tr>
<tr>
<td><strong>F Technical Concentration</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Eigenvalue=2.57 % of variance explained=64.14)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Only a few production people is knowledgeable of production technologies*</td>
<td>0.77</td>
<td>0.81</td>
</tr>
<tr>
<td>2 Only a few production people have is knowledgeable of statistical techniques</td>
<td>0.82</td>
<td></td>
</tr>
<tr>
<td>3 Many production people are knowledgeable of problem solving tools</td>
<td>0.87</td>
<td></td>
</tr>
<tr>
<td>4 Only a few production people are knowledgeable of process analysis*</td>
<td>0.75</td>
<td></td>
</tr>
</tbody>
</table>

*The 11th International DSI and the 16th APDSI Joint Meeting, Taipei, Taiwan, July 12 – 16, 2011, pp.565-575
Reliability. The threshold for Cronbach’s alpha [57] was set at 0.60, in order to assess the adequacy of subscale reliability. As shown in Table 1, the results reveal that all constructs fulfill the criterion for reliability.

Convergent Validity. Two criteria were used to assess convergent validity. First, the factor loadings of the measurement items of the corresponding constructs should be statistically significant [12]. Second, each indicator’s factor loadings on its posited underlying construct factor should be significantly greater than twice its standard error [3]. Using the 230 validation samples, all scales showed significant loadings at p < 0.05. In addition, all of the factor loadings are greater than twice their standard error (results are not shown here). Based on these results, the scales exhibit acceptable convergent validity.

Discriminant Validity. We tested discriminant validity following [3]. Discriminant validity is confirmed if the value 1.00 is outside the range of the correlation coefficient of any two factors, that is, r ± 2Se(r). The results show that no correlation coefficient bears a value of 1.00 within the range of r ± 2Se(r)(results are not shown here) Therefore, discriminant validity is statistically confirmed.

RESULT AND DISCUSSION

The structural model as shown in Figure 1 was tested based on all the 330 samples. It demonstrates a rather good fit with the data: \( \chi^2=334.9 \) df=189, \( \chi^2/df=1.77 \), RMSEA=0.048 [0.040, 0.057], CFI=0.94, TLI=0.92, GFI=0.92. The result, as shown in Table 3 and Table 4, reveals that first, H1 is partially supported because only the incremental process improvement tactics positively influences the adoption of the radical process improvement. To our surprise, the incremental process improvement strategy does not have any significant effect on the radical process improvement. Furthermore, the incremental process improvement tactics is the strongest influence on the adoption of the radical process improvement among others (\( \gamma=0.443, p<0.001 \)). Even though proliferate of studies, e.g., [13][14][43][54][68] suggest that the incremental process improvement will trigger the radical process improvement, this study sheds light on this issue by clarifying that it is not the strategies but the actual way of implementing the incremental process improvement matters. One possible explanation may be in congruence with the thought that the repeated adoption of the incremental process improvement tactics enhances the employees’ work efficiency and proficiency [13][75][64]. This is achieved through learning and accumulation of problem solving knowledge and capabilities [77][26] and results in more courageous employees who are willing to adopt more radical process improvement practices.

Second, institutional pressure is found significantly affecting the adoption of incremental process improvement strategy (\( \gamma=0.285, p<0.001 \)) but not the tactics and radical process improvement. Therefore, H2 is partially supported whereas H3 is rejected. In addition, the effect of institutional pressure on incremental process improvement is apparently stronger than that on radical process improvement. Therefore, H4 is supported as well. These findings provide insight about the actual impact of institutional pressure on the adoption of process improvement. Particularly, the pressure which favors the incremental process improvement, may not be able to stipulate the detail approach that organizations use to improve the processes. Instead, it determines the direction that organizations’ improvement activities should follow suit. Thinking along this line, we can postulate that even organizations in the same industry may experience similar institutional pressure and respond in a similar improvement direction, the actual way of improvement will be different across organizations and thus results in differential performances. Therefore, even though the literature suggests that the institutional pressures force organizations to comply for legitimacy and results in homogeneity among organizations [22], this study reveals that institutional pressure virtually urges organizations to comply incremental improvement at the strategic level rather than the operational level that causes the difference. In addition, the rejection of H3 and support of H4 confirms our postulation that firms pay more attention to institutional pressure will be reluctant to take risk in radically changing their processes.

Third, according to Table 3, management pro-activities is the most versatile motive among others for the adoption of process improvement practices. It has the strongest influence on the adoption of incremental process improvement strategy (\( \gamma=0.304, p<0.001 \)) and tactics (\( \gamma=0.409, p<0.001 \)). It also fairly strongly drives the adoption of radical process improvement (\( \gamma=0.389, p<0.001 \)). Therefore, H5 and H6 are supported. Notwithstanding the significance of this effect, to our surprise, the role of management’s personal initiative [7][80] is seldom considered in literature as a determinant of adoption of operations practices. In fact, even though it is one of the key dimensions of strategic orientations of business enterprises from the perspective of strategic management [80], its role in operations management and the relationship with operations practices is hitherto, unexplored in the operations management literature. Perhaps, it is because the literature has downplayed the role of organizational self-interests and active agencies in organizational adaptation to requirements of institutional environment [15][31][58]. Nevertheless, our finding reveals that it is the most important driving force for adoption in the presence of external institutional pressure and the internal technical resources. Last, H7 is marginally supported because the effect of management pro-activities on radical process improvement is stronger than that on incremental process improvement strategy but is weaker than that on tactics.

Fourth, as shown in Table 3, technical concentration weakly influences incremental process improvement strategy (\( \gamma=0.143, p<0.05 \)), and has insignificant effect on incremental process improvement tactics. Therefore, H8 is weakly supported. But, its impact on the adoption of radical process improvement is fairly strong (\( \gamma=0.394, p<0.001 \)), so H9 is supported. When comparing the impacts on incremental process improvement with that on radical
process improvement, obviously, the latter is stronger. In this connection, \( H_0 \) is also supported and hence it is confident to believe that technical concentration will be more likely to elicit radical process improvement than incremental process improvement. After all, these findings suggest that knowledge-based view may not be adequate to explain the adoption behavior of process improvement. Even though technical knowledge is always believed to be the source of competitive advantage [24][28], our study finding indicates that “it depends.” Specifically, if an organization is in a rather stable environment that the capability of incremental process improvement is crucial [9], increase of technical resources may not be the appropriate winning formulae.

**MANAGERIAL IMPLICATIONS**

This study bears several managerial implications. First, while institutional pressure may drive managers to change their improvement strategy, managers should be aware that these pressures may not be able to signal the need for radical process improvement when the firm is in crisis nor to trigger the use of improvement tactics to pragmatically improve the operations. Second, whether operations will incrementally and/or radically improve their process is always hinged upon the pro-activeness of managers. In other words, managers lacking pro-activeness not only will be incapable of reacting responsively to a crisis but will also find themselves handicapped of improving and stabilizing the operations in their daily duties. Finally, managers should carefully acquire and/or develop their technical resources because it all depends on what kind of process improvement is needed.

**Table 3 Path coefficients (N=330)**

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Incremental process improvement strategy</th>
<th>Incremental process improvement tactics</th>
<th>Radical process improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Institutional pressure</td>
<td>0.285***</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
<tr>
<td>Management pro-activeness</td>
<td>0.304***</td>
<td>0.409***</td>
<td>0.389**</td>
</tr>
<tr>
<td>Technical concentration</td>
<td>0.143*</td>
<td>n.s.</td>
<td>0.394***</td>
</tr>
<tr>
<td>Organizational size</td>
<td>n.s.</td>
<td>0.075*</td>
<td>n.s.</td>
</tr>
<tr>
<td>Incremental process improvement strategy</td>
<td>0.249*</td>
<td>n.s.</td>
<td></td>
</tr>
<tr>
<td>Incremental process improvement tactics</td>
<td>0.443***</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 4. Hypothesis Test Summary**

<table>
<thead>
<tr>
<th>No.</th>
<th>Hypotheses</th>
<th>Reject or Support?</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>The more adoption of incremental process improvement the more implementation of radical process improvement.</td>
<td>Partially supported</td>
</tr>
<tr>
<td>H2</td>
<td>Institutional pressure positively influences the adoption of incremental process improvement.</td>
<td>Partially supported</td>
</tr>
<tr>
<td>H3</td>
<td>Institutional pressure positively influences the adoption of radical process improvement.</td>
<td>Rejected</td>
</tr>
<tr>
<td>H4</td>
<td>Institutional pressure imposes stronger influence on the adoption of incremental process improvement than that of radical process improvement.</td>
<td>Supported</td>
</tr>
<tr>
<td>H5</td>
<td>Management pro-activeness positively influences the adoption of incremental process improvement.</td>
<td>Supported</td>
</tr>
<tr>
<td>H6</td>
<td>Management pro-activeness positively influences the adoption of radical process improvement.</td>
<td>Supported</td>
</tr>
<tr>
<td>H7</td>
<td>Management pro-activeness imposes stronger influence on the adoption of incremental process improvement than that of radical process improvement.</td>
<td>Partially supported</td>
</tr>
<tr>
<td>H8</td>
<td>Technical concentration positively influences the adoption of incremental process improvement.</td>
<td>Weakly supported</td>
</tr>
<tr>
<td>H9</td>
<td>Technical concentration positively influences the adoption of radical process improvement.</td>
<td>Supported</td>
</tr>
<tr>
<td>H10</td>
<td>Technical concentration imposes stronger influence on the adoption of radical process improvement than that of incremental process improvement.</td>
<td>Supported</td>
</tr>
</tbody>
</table>

*** denotes the path coefficient is significant at \( p<0.05 \), 0.01, 0.001 respectively.
LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

It is the first study addressing the simultaneous effect of different motives on the adoption of various process improvement practices, thus may bear some limitations that the results should be interpreted cautiously. First, as all the samples are manufacturing firms, the results are by no means representative of those in servicing industries. The motives may be different between the two industries, so are the process improvement practices [85]. Therefore, it is fruitful to conduct a similar study for service industries such that cross-industry study becomes possible. Second, as this study is based on one informant from each organization, the study may therefore have potential suffering from common-method bias. Nevertheless, the inferior one-factor model fitness ($\chi^2/df=153, \chi^2/df=13.06$, RMSEA=0.019, $\chi^2/df=0.01$, TLI=.01, GFI=.43) shows that such bias may not be a threat to this study. Notwithstanding the weak evidence of common method bias of this study, it is nevertheless a good practice in empirical research having multiple informants in each organization. Finally, there may not be enough exploration for the effect of control variables in this study. Though organization size has been included, other factors should also be considered in future. For instance, the experience of quality management would affect the adoption of process improvement. It is because organizations which are more experienced in quality management, will use their resources more effectively [1,29], and will be more experienced in process management [29].

CONCLUSIONS

In this study, we strive to contribute to three issues related to the adoption of process improvement practices. First, this study provides a comprehensive view of how organizations are motivated to adopt process management practices. The current theories about the motives for the adoption of process management practices are segmented, without considering the coexistence of different theoretical perspectives, thus narrowing our view and limiting our understanding of the lifelike reality that organizations experience. Second, this study aims at providing a more precise estimation of the effect of institutional pressures on the adoption of process management practices. Other research, which investigates the effect of institutional pressures without controlling other environmental effects, may lead to immature conclusions about adoption behavior and overestimates of the effect size. Finally, this study projects a novel outlook to explain process management practice adoption, by taking into account the personal initiative of managers, and the technical concentration. These elements are found versatile in explaining the adoption behavior that previous studies may overlook.

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SHOP-FLOOR COMMUNICATION AND PRACTICES FOR OPERATIONAL PERFORMANCE: AN EMPIRICAL ANALYSIS OF QUALITY MANAGEMENT

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ABSTRACT
This paper aims to provide a research framework for studying the role of communication in supporting quality management (QM) practices at the shop floor level to obtain high operational performance. It attempts to investigate the relationship between shop-floor communication and QM practices and their impact on operational performance. The result shows the shop-floor communication has an indirect impact on operational performance mediated by the implementation of QM practices on the shop floor.

Keywords: communication, quality management, operational performance, shop floor, structural equation modeling

INTRODUCTION
The empirical research on quality management (QM) has evolved over the last two decades. Numerous studies have investigated the relationships among QM practices and organizational performance on various levels. Even though the existing literature of quality management (QM) and various quality awards have regarded communication as an important factor for the successful implementation of QM, there are little attempts to link communication and QM practices in achieving high operational performance. Some researchers, though have emphasized the significance of communication and information management in successful implementation of QM [1, 2], did not propose any analytical frameworks for further empirical investigation. Forza [3] pioneered this effort through studying the role of quality information systems in QM from a perspective of information flow. Later on, Forza and Salvador [4] proposed a comprehensive framework for analyzing the information flows taken place within process communication network in supporting the implementation of management best practices (total quality management, just-in-time etc.), which lent a strong foundation for further empirical study. Sila and Ebrahimipoor [5], having conducted an intensive review of the critical factors in the existing QM literature, pointed out the scarcity of studies dealing with the role of communication in effective QM implementation in detail. They also suggested three areas on this issue that need more studies: the mechanisms or channels to communicate QM; the types of communication methods and their role in QM; and the impact of the Internet technologies on QM.

Responding to this need, this study aims to provide a research model to study the role of communication in supporting QM practices to obtain high operational performance, at the shop floor level. In particular, it attempts to answer the following research questions:
RQ1. What is the relationship between communication and QM practices at the shop floor level?
RQ2. How do shop-floor communication and QM practices on the shop floor impact on operational performance?
This study contributes to the literature by extending our understanding of the role of communication in QM implementation on the shop floor and enriching our knowledge of how to achieve and improve operational performance through leveraging communication.

RESEARCH MODEL
Figure 1 shows a research model for studying the role of communication in supporting QM practices with the objective of attaining high operational performance. The model contains the following three dimensions: shop-floor communication, process management, and operational performance.

The dimension “shop-floor communication” considers communication directed to the shop floor to support the shop-floor personnel to improve quality performance. It includes three types of communication as follows:
Teamwork: group communication taken place on the shop floor in order to solve quality problems
Feedback: provides the shop-floor personnel with information regarding their performance in a timely and useful manner.
Training: instructive communication directed to the shop-floor personnel providing skills, knowledge, expertise, etc. for their proper execution of multiple tasks or jobs.

The dimension “process management” represents activities and approaches typical of QM practices on the shop floor. It includes three practices as follows:

Process control: the use of statistical process control to maintain control over production processes in order to reduce variance.
Preventive maintenance: a schedule of planned maintenance actions aimed at the prevention of breakdowns and failures.

Cleanliness and Organization: steps are taken to organize the work-place and maintain it in order to help employees accomplish their jobs faster and instill a sense of pride in their work-place.

The dimension “operational performance” includes four performance measures in the context of manufacturing plants: unit cost of manufacturing, conformance to product specifications, on-time delivery performance and flexibility to change volume. These items were summed up to form an overall operational performance.
In order to implement and promote the process management effectively, the results related to detected process variations and quality problems need to be intensively discussed, analyzed and shared on the shop floor to solve the problems [7]. This needs the facilitation through communication activities such as shop-floor information feedback, group communication, instructive communication, etc. Therefore, the following hypothesis is suggested:

H1: Shop-floor communication is positively related to process management.

Effective process management is expected to reduce process variation, enhance process capability, and thus decrease the likelihood of defective parts [6]. As the defective is reduced, less time and money will be spent on rework and inspection at the machine shop, allowing the production run faster and more smoothly and thus leading to better operational performance. Thus, we propose that

H2: Process management is positively related to operational performance.

Shop-floor communication enables a direct and effective communication between workers, fostering not only information exchange, but also the exchange of their feelings [8]. As a result, workers are expected to work more effectively in a cooperative environment and execute better tasks with fewer defectives. This lead to the following hypothesis:

H3: Shop-floor communication is positively related to operational performance.

The primary research instruments for this study are rigorously validated measurement scales and survey data collected through an extensive questionnaire. Data are acquired from 184 manufacturing plants in 6 countries: the United States, Japan, Italy, Australia, Korea, and Germany during 2003-2004. Those plants belong to three industries: electrical & electronics, machinery, and transportation equipment. The six scales for shop-floor communication and process management were evaluated by people at eight different positions through perceptual question items on the seven-point Likert scale, where a value of one indicated ‘strongly disagree’ and a value of seven indicated ‘strongly agree.’ Meanwhile, the measures of operational performance were judged by the plant manager on the five-point Likert scale. All the measurement scales were tested for reliability and validity through calculating the Cronbach’s alpha and the confirmatory factor analysis. The items which undermined the validity or reliability were eliminated.

Structural equation modeling was used to test the Hypotheses followed by a regression model to test the linkages among the three constructs at a more detailed level. A number of indices were used to determine the fit of the data to the model (Table 1). An analysis of the t-value revealed that the relation between “shop-floor communication” and “operational performance” is not statistically significant (t-value=1.311; standardized estimate of the coefficient=1.125), and so is between “process management” and “operational performance.”

Fig. 1: The hypothesized model

Fig. 2: The revised model
Table 1: Fit measures of overall model

<table>
<thead>
<tr>
<th>Fit index</th>
<th>Chi-square test statistic</th>
<th>Degrees of freedom</th>
<th>Normed chi-square</th>
<th>RMSEA</th>
<th>CFI</th>
<th>PNFI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypothesized structural model</td>
<td>59.091</td>
<td>12</td>
<td>4.924</td>
<td>0.146</td>
<td>0.925</td>
<td>0.390</td>
</tr>
<tr>
<td>Revised structural model</td>
<td>61.925</td>
<td>13</td>
<td>4.763</td>
<td>0.143</td>
<td>0.922</td>
<td>0.421</td>
</tr>
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</table>

Table 2: Regression results

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>R2</th>
<th>Adjusted R2</th>
<th>F</th>
<th>Sig</th>
<th>Independent variables</th>
<th>Beta</th>
<th>t-value</th>
<th>Sig</th>
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</thead>
<tbody>
<tr>
<td>Process Control</td>
<td>.591</td>
<td>.584</td>
<td>86.731</td>
<td>.000</td>
<td>(Constant)</td>
<td>.651</td>
<td>1.896</td>
<td>.060</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Teamwork</td>
<td>.154</td>
<td>1.956</td>
<td>.052</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Feedback</td>
<td>.619</td>
<td>9.360</td>
<td>.000</td>
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<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>Training</td>
<td>.063</td>
<td>.983</td>
<td>.327</td>
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<tr>
<td>Preventive Maintenance</td>
<td>.436</td>
<td>.426</td>
<td>46.317</td>
<td>.000</td>
<td>(Constant)</td>
<td>1.001</td>
<td>2.923</td>
<td>.004</td>
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<tr>
<td></td>
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<td>Teamwork</td>
<td>.253</td>
<td>2.729</td>
<td>.007</td>
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<tr>
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<td>Feedback</td>
<td>.233</td>
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<td>.003</td>
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<td>Training</td>
<td>.284</td>
<td>3.804</td>
<td>.000</td>
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<tr>
<td>Cleanliness and Organization</td>
<td>.425</td>
<td>.415</td>
<td>44.304</td>
<td>.000</td>
<td>(Constant)</td>
<td>2.134</td>
<td>5.790</td>
<td>.000</td>
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<tr>
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<td></td>
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<td>Teamwork</td>
<td>.472</td>
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<tr>
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<td></td>
<td>Feedback</td>
<td>.156</td>
<td>2.728</td>
<td>.049</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Training</td>
<td>.089</td>
<td>1.729</td>
<td>.238</td>
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<tr>
<td>Operational Performance</td>
<td>.239</td>
<td>.222</td>
<td>14.100</td>
<td>.000</td>
<td>(Constant)</td>
<td>1.256</td>
<td>3.061</td>
<td>.003</td>
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<td></td>
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<td>Process control</td>
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<td>1.855</td>
<td>.066</td>
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<td></td>
<td></td>
<td>Preventive Maintenance</td>
<td>.196</td>
<td>2.177</td>
<td>.031</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>Cleanliness and Organization</td>
<td>.224</td>
<td>2.373</td>
<td>.019</td>
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</tbody>
</table>

performance” (t-value=-0.670; standardized estimate of the coefficient=-0.571). According to SEM theory, the non-significant path from “shop-floor communication” to “operational performance” was deleted, while other paths still remains to keep the meaning of this conceptual model. The standard coefficients for the revised structural model are shown in Figure 2. All of the coefficients are significant at the 1% level, making the research model meaningful despite the mediocre fit indicated by fit measures (Table 1). Regression analysis was then conducted to test the relationship remained in the revised structural model in detail: the impact of shop-floor communication on process management and that of process management on operational performance (Table 2). The results can be summarized as follows:

Teamwork and feedback positively and significantly impact on all dimensions of the process management.

Training positively and significantly impacts only on preventive maintenance, and has a positive but non-significant impact on other two dimensions of the process management.

Process management, particularly cleanliness & organization and preventive maintenance, positively and significantly impact on operational performance.

Thus, the above analysis supports hypothesis H1 and hypothesis H2, while it rejects hypothesis H3.

CONCLUSIONS

This study highlights the role of communication in supporting QM practices to achieve operational performance at the shop floor level. First, we can find that the implementation of QM practices on the shop floor strongly associates with shop-floor communication in terms of group communication (teamwork), instructive communication (training) and
feedback. This finding empirically supports the claim that the successful implementation of best management practice such as QM heavily dependents on effective communication [1]. Further, we confirm the positive relationship between QM practices and operational performance, which is in line with previous QM studies [6, 9]. To be more important, our study detects that the shop-floor communication does not have a direct impact on operational performance, but has an indirect impact on operational performance mediated by the implementation of shop-floor QM practices. This indicates that shop-floor communication, instead of being implemented alone, needs to be jointly implemented with shop-floor QM practices in order to achieve higher operational performance.

ACKNOWLEDGMENT

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REFERENCES

EMPIRICAL STUDY ON TRANSFERABILITY OF KAIZEN PRACTICES
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Yoshiki Matsui, Yokohama National University, Japan, ymatsui@ynu.ac.jp

ABSTRACT
Kaizen is Japanese business strategy that calls for never ending effort for improvement involving everyone in the organization, from managers to workers. This study examines the influence of the national and organizational culture on the transferability of Kaizen. Statistical techniques are applied to database collected through the questionnaire survey of 238 manufacturing plants in 8 countries. The findings indicate that Kaizen practices are significantly related to low power distance, low uncertainty avoidance, female, and collectivism. In addition, the Kaizen implementation would be more successful in manufacturing plants having low centralization of authority and high cross-functional cooperation.

Keywords: Kaizen Practices, Transferability, National Culture, Organizational Culture, Manufacturing Plants

INTRODUCTION
Kaizen has been regarded as a key element in Japanese management and has been presented as one of the sources of the competitiveness of Japanese manufacturers. Since late of the 1980s, a larger number of studies, which have focused on different Kaizen systems, approaches and practices such as Japanese manufacturing techniques [2][15], the Toyota production system [9][12], and lean production [16], have illustrated the effectiveness of Kaizen. Furthermore, studies of kaizen activities in the countries outside Japan, such as US, China, Australia, Sweden and the UK suggest that the concept, approaches, and practices of Kaizen have become routinely accepted throughout the world. However, literature indicates that, as Kaizen is introduced to overseas operations following the Japanese corporate expansion activities, the performance of Kaizen implementation is contextual dependent. Some scholars indicated that Kaizen practices were embedded in the Japanese culture and difficult to transfer abroad while others suggested that only the rational aspects of those practices were transferable overseas. Recent studies show that Kaizen approaches were not easily adopted in abroad due to such environmental factors as the differences in national culture and working ethics. Along with national culture aspects, scholar argued that the adoption of Kaizen highly depends on some specific organizational culture such as centralization of authority and cross-functional cooperation [13].

This study focuses on the transferability of Kaizen approach abroad by analyzing the relationship between the implementation of Kaizen practices, national culture, and organizational culture to answer the following research questions:

- Is the level of the implementation of Kaizen practices related to the national culture?
- Is the level of the implementation of Kaizen practices related to the organizational culture?

We apply the statistical techniques such as ANOVA, correlation analysis, and regression to database collected through the questionnaire survey of 238 plants in 8 countries after 2003. The findings indicate that the Kaizen implementation is significantly related to low power distance, low uncertainty avoidance, female, and collectivism. In addition, Kaizen practices could be more easily implemented in manufacturing plants having low centralization of authority and high cooperation between managers, workers, customers, and suppliers. We conclude that transferability of Kaizen practices strongly depends on cultural perspectives in both national and organizational level. This paper is presented as follows. The next section summarizes the literature review and framework of this study. The third and fourth sections present the collection of data, analytical process, and the conclusion of this study.

LITERATURE REVIEW AND ANALYTICAL FRAMEWORK
Kaizen is a hot topic in Japanese management studies over the past few decades. Although there are a number of studies on transferability of the Japanese management practices, the concept of Kaizen has been presented in different way. This study adopts the concept of Kaizen from Masaaki Imai who presents Kaizen as pervasive global program, which subsumes to TQM, just-in-time (JIT), and total productive maintenance (TPM) [7][8]. One of example of Kaizen practices is the employee suggestion that aims at generating many small improvement and morale boosting benefits of positive employee participation. Literature indicates that, a total of 60 to 70 suggestions per employee per year are written down, shared, and implemented in Toyota Motor Company [9].

As recognized as a core of Kaizen, QC Circle activities has been initiated by Union of Japanese Scientists & Engineers (JUSE) in 1962 with the objective is to develop members' capabilities and achieve self-actualization, make the workplace more pleasant, vital and satisfying, improve the customer satisfaction, and contribute to the society. Recently, QC Circle is expanded to more than 70 countries and regions and gives significantly contribution to the improvement of quality performance over the world [9][12]. Autonomous maintenance refers to the practice designed to involve operators in maintaining their own equipment. Autonomous maintenance is regarded as a key component of TPM, which has initiated by the Japan Institute of Plant Maintenance (JIPM) in 1971 based on maintenance.
concepts developed in the United States in the 1950s. TPM Excellent Awards have been awarded to some 2,000 plants since its establishment in 1964. Recently, autonomous maintenance and other TPM techniques are widely expanded to other countries and region such as India, Thailand, and Taiwan.

The studies on transferability of kaizen practices suggest that the implementation of Japanese continuous improvement practices in the overseas plants is situated in cultural and social context [1] [6] [14]. While national culture is defined as collective programming of mind that distinguishes members of one group from another, organizational culture is regarded as the specific collection of values and norms that are shared by people and groups in an organization and that control the way they interact with each other and with stakeholders outside the organization. When Kaizen practices are adopted in an organization, those factors would moderate the teamwork, decision-making process for problem solving, and autonomous activities. To study the transferability of Kaizen, Hofstede’s approach is selected in this study because it sharply differentiates between national and organizational cultural components. We would like to examine how such Hofstede’s national cultural dimensions as Power distance, Uncertainty avoidance, Individualism/collectivism, Masculinity/femininity. Power distance is the extent to which people believe that the power and status are distributed and unequal distribution is accepted as a proper way for social systems to be organized. Power distance influences the amount of formal hierarchy, the degree of centralization and the amount of participation in decision making in organizations. The plants that are located in high power distance countries tend to be more centralized and employees participate less in decision making. Implementation of such Kaizen practices as group problem solving or autonomous activities requires empowerment and participative decision making, which mirrors low power distance. Uncertainty avoidance is the degree to which people within a culture are made uncomfortable by situations they perceive to be unstructured, unclear or unpredictable [5] [6]. In organizations, clarity of plans, policies, procedures and systems helps to avoid uncertainty. Kaizen practices emphasizes on the improvement of processes through scientist improvement methods and statistical process control. This relates to the cultures with high uncertainty avoidance, which greater emphasizes on procedure and routines. Individualism/collectivism describes the degree to which people are oriented towards acting as individuals versus acting as part of a group [5] [6]. Literature on Kaizen studies indicated that the implementation of Kaizen requires cooperation, teamwork, and joint decision-making. Masculinity/femininity describes the extent to which aggressiveness and success are valued, versus concern for relationships [5] [6].

As indicated in the literature, the Japanese culture made possible a commitment to quality throughout the ranks as had existed in no other country before [5]. According to Hofstede, Japanese culture is characterized by long-term orientation (LTO=80), high uncertainty avoidance (UAI=92), moderate power distance (PD= 54), moderate individualism (IDV=46), and strong masculinity (MAS=95). These characteristics allow the Japanese to learn and widely implement the Western quality management techniques in manufacturing companies and achieve high performance.

Table 1: Hofstede five national culture dimensions

<table>
<thead>
<tr>
<th>Country</th>
<th>Power Distance (PDI)</th>
<th>Individualism (IDV)</th>
<th>Masculinity (MAS)</th>
<th>Uncertainty Avoidance(UAI)</th>
<th>Long-term Orientation (LTO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Korea</td>
<td>60</td>
<td>18</td>
<td>39</td>
<td>85</td>
<td>75</td>
</tr>
<tr>
<td>Japan</td>
<td>54</td>
<td>46</td>
<td>95</td>
<td>92</td>
<td>80</td>
</tr>
<tr>
<td>Italy</td>
<td>50</td>
<td>76</td>
<td>70</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>40</td>
<td>91</td>
<td>62</td>
<td>46</td>
<td>29</td>
</tr>
<tr>
<td>Germany</td>
<td>35</td>
<td>67</td>
<td>66</td>
<td>65</td>
<td>31</td>
</tr>
<tr>
<td>Austria</td>
<td>11</td>
<td>55</td>
<td>79</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>Finland</td>
<td>33</td>
<td>63</td>
<td>26</td>
<td>59</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>31</td>
<td>71</td>
<td>5</td>
<td>29</td>
<td>33</td>
</tr>
</tbody>
</table>

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We would like to examine that whether Kaizen practices can be adopted in other environment rather than Japan. Three typical Kaizen practices are used in this study as follows:

- Small Group Problem Solving: plants use the small group/team to solve the quality problems
- Employee’s Suggestion: plants implement the employee suggestion and give feedback to the employees
- Autonomous Maintenance: the operators rather than the maintenance staff to daily inspect and monitor the equipment performance

Along with national culture, we focused on three different aspects organizational culture as follows:

- Centralization of Authority: degree of freedom for an individual in the organization
- Cooperation: cooperation between managers, workers, customers, and suppliers
- Process Emphasis: plants focus on process improvement

Based on literatures, we establish two hypotheses on the relationship between Kaizen practices and Hofstede’s national culture and organizational culture perspectives. The first hypothesis on relationship of national culture and Kaizen practices is presented as follows.

Hypothesis 1: Scores on the Kaizen constructs will be:
- Lower in countries with high power distance cultures.
- Low in countries with higher levels of uncertainty avoidance.
- Lower in countries with higher levels of individualism.
- Lower in countries with more masculine cultures

We assume that three aspects of organizational cultures are strongly related with the transformation of Kaizen practices. The implementation of Kaizen practices requires low centralization of authority and cooperation between managers, workers, customers, and suppliers to improve products and processes. In addition, Kaizen practices would be easily adopted in the plants that more emphasize on processes rather than products. The second hypothesis on the relationship of organizational culture and Kaizen practices is presented as follows.

Hypothesis 2: Scores on the Kaizen constructs will be:
- Lower in plants with high centralization of authority.
- Higher in plants with higher levels of cooperation.
- Higher in plants with more process emphasis.

The next section will present the process of hypotheses testing

DATA COLLECTION

This study acquires data collected from 238 manufacturing plants in 8 countries: Austria (21), Finland (30), Germany (41), Italy (27), Japan (35), Korea (31), Sweden (24), and the United States (29) from questionnaire survey after 2003. Those plants belong to three industries: electronic (79), machinery (78), transportation (81). Questionnaire on Kaizen practices and organizational culture are evaluated by eight positions from Direct Labor to Plant Manager on a seven-point Likert scale (1 = strongly disagree, 4 = neither agree nor disagree, 7 = strongly agree).

- Small Group Problem Solving is evaluated by Direct Labor, Quality Manager, and Supervisor
- Employee Suggestion is evaluated by Direct Labor, Process Engineer, and Supervisor
- Autonomous Maintenance is evaluated by Process Engineer, Supervisor, and Plant Superintendent
- Centralization of Authorities is evaluated by Direct Labor, Human Resource, and Supervisor
- Cooperation is evaluated by Inventory Manager, Plant Manager and Supervisor
- Process Emphasis is evaluated by Process Engineer, Supervisor, and Plant Superintendent

The first step of analytical process is the analysis of reliability and validity which are performed to evaluate the measurement properties of the individual scales. Reliability is an estimate of measurement consistency. In this study, Cronbach’s alpha coefficient is calculated for each scale to evaluate the reliability. Table 2 shows the alpha values for all scales exceeded the minimum acceptable alpha value of 0.60 (Nunnally, 1967). Most of the scales have alpha value above 0.70 indicating that the scales are internally consistent.

Next, the validity of measurement scales was tested against content and construct. Content validity: An extensive review about empirical literature on quality management and organization performance was conducted to ensure content validity. This study continues the works of Schroeder and Flynn (2001); that developed and tested a set of measurement scales of management practices in the framework of HPM Project.

Construct validity: Construct validity is tested to ensure that in a scale, all question items measure the same construct. Within scale factor analysis was conducted with the three criteria as follows: (a) uni-dimensionality, (b) a minimum eigenvalue of 1, (c) item factor loadings should be greater than 0.40. The results show that all scales had good construct validity. Table 2 shows that the eigenvalue of the first factor is all more than 1.90 for each scale. The factor loading for each item (shown in appendix) is more than 0.40, mostly ranged between 0.70 and 0.90 indicating the high validity of the measurement scales.
Table 2. Measurement Test

<table>
<thead>
<tr>
<th>Measurement construct</th>
<th>Cronbach Alpha</th>
<th>Eigenvalue (% variance)</th>
<th>Min.</th>
<th>Max.</th>
<th>Mean</th>
<th>Std.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Group Problem Solving</td>
<td>0.82</td>
<td>3.21 (53)</td>
<td>3.39</td>
<td>6.83</td>
<td>5.05</td>
<td>0.64</td>
</tr>
<tr>
<td>Employee Suggestion</td>
<td>0.83</td>
<td>3.03 (61)</td>
<td>3.47</td>
<td>6.80</td>
<td>5.18</td>
<td>0.64</td>
</tr>
<tr>
<td>Autonomous Maintenance</td>
<td>0.70</td>
<td>2.13 (53)</td>
<td>3.05</td>
<td>6.58</td>
<td>5.09</td>
<td>0.62</td>
</tr>
<tr>
<td>Centralization of Authority</td>
<td>0.76</td>
<td>2.02 (67)</td>
<td>1.33</td>
<td>5.48</td>
<td>3.49</td>
<td>0.86</td>
</tr>
<tr>
<td>Cooperation</td>
<td>0.75</td>
<td>2.67 (45)</td>
<td>4.42</td>
<td>6.87</td>
<td>5.74</td>
<td>0.42</td>
</tr>
<tr>
<td>Process Emphasis</td>
<td>0.60</td>
<td>1.70 (57)</td>
<td>3.33</td>
<td>6.33</td>
<td>4.50</td>
<td>0.56</td>
</tr>
</tbody>
</table>

HYPOTHESIS TESTING

Analytical process starts with the analysis of country-effect on Kaizen practices and organizational culture as shown in Table 3. Tukey pair-wise comparison tests of mean differences are conducted to identify how of Kaizen practices and organizational culture aspects differed between each pair of countries. We find the slight differences between the countries Small Group Problem Solving (Finish plants versus US and Italian plants), Employee’s Suggestion (Finish plants versus Italian plants), and Autonomous Maintenance (Finish plants versus US and Japanese plants, US plants versus Korean and Austrian plants, and Japanese plants versus Korean and Austrian plants).

We observe the large difference on organizational culture aspects between the countries, especially on Centralization of Authority. Swedish and Finish plants attribute higher degree of authority decentralization than other countries. An interest finding is Japanese plants give less focus on process than other countries.

Next, correlation analysis is conducted to find out the correlation between Kaizen practices, national culture dimensions, and organizational cultures aspects as shown in Table 4. The link between Kaizen practices and organization culture aspects appear tight.

We find that every Kaizen practices are negatively related with Centralization of Authority and positively related with Cooperation. Autonomous Maintenance is positively related to Process Emphasis. The link between Kaizen practices and Hofstede’s national culture dimension appear weak.

- Small Group Problem Solving is negatively related to scores on Power Distance and Uncertainty.
- Employee Suggestion is negatively related to score on Masculinity.
- Process Emphasis is negatively related to scores on Power Distance, Individualism, and Masculinity.

To test the hypotheses formally, stepwise regression is conducted to find out the impact of the national culture dimensions and organizational cultures aspects on Kaizen practices as shown in Table 5 which presents the best models with highest explanation power for three Kaizen practices.
### Table 3: Degrees of Kaizen Practices and Organizational Cultures Aspects Classified by Country

<table>
<thead>
<tr>
<th>Aspect</th>
<th>AUT</th>
<th>FIN</th>
<th>GER</th>
<th>ITA</th>
<th>JPN</th>
<th>KOR</th>
<th>SWE</th>
<th>US</th>
<th>F test</th>
<th>Sig.</th>
<th></th>
<th>Tukey pair-wise test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Group Problem Solving</td>
<td>5.35</td>
<td>4.88</td>
<td>4.96</td>
<td>4.87</td>
<td>4.92</td>
<td>5.02</td>
<td>5.22</td>
<td>5.33</td>
<td>3.06</td>
<td>0.00</td>
<td>FIN vs. (US and AUT)</td>
<td></td>
</tr>
<tr>
<td>Employee’s Suggestion</td>
<td>5.27</td>
<td>5.48</td>
<td>5.13</td>
<td>4.78</td>
<td>5.18</td>
<td>5.22</td>
<td>5.27</td>
<td>5.10</td>
<td>2.34</td>
<td>0.03</td>
<td>FIN vs. ITA</td>
<td></td>
</tr>
<tr>
<td>Autonomous Maintenance</td>
<td>5.37</td>
<td>5.44</td>
<td>5.08</td>
<td>4.95</td>
<td>4.81</td>
<td>5.32</td>
<td>5.01</td>
<td>4.86</td>
<td>4.49</td>
<td>0.00</td>
<td>FIN vs. (US and JPN), US vs. (KOR and AUT), JPN vs. (KOR and AUT)</td>
<td></td>
</tr>
<tr>
<td>Centralization of Authority</td>
<td>3.18</td>
<td>2.43</td>
<td>3.23</td>
<td>4.31</td>
<td>4.04</td>
<td>4.23</td>
<td>2.85</td>
<td>3.47</td>
<td>32.30</td>
<td>0.00</td>
<td>JPN vs. (GER and AUT), KOR vs. AUT</td>
<td></td>
</tr>
<tr>
<td>Cooperation</td>
<td>6.00</td>
<td>5.77</td>
<td>5.91</td>
<td>5.68</td>
<td>5.60</td>
<td>5.64</td>
<td>5.67</td>
<td>5.71</td>
<td>3.22</td>
<td>0.00</td>
<td>JPN vs. (GER and AUT), KOR vs. AUT</td>
<td></td>
</tr>
<tr>
<td>Process Emphasis</td>
<td>4.59</td>
<td>4.92</td>
<td>4.63</td>
<td>4.44</td>
<td>3.96</td>
<td>4.51</td>
<td>4.52</td>
<td>4.50</td>
<td>10.56</td>
<td>0.00</td>
<td>FIN vs. (US, JPN, GER, SWE, KOR, and ITA), US vs. JPN, JPN vs. (GER, SWE, KOR, and AUT)</td>
<td></td>
</tr>
</tbody>
</table>

### Table 4: Correlation Analysis

<table>
<thead>
<tr>
<th>Correlation Matrix</th>
<th>Small Group Problem Solving</th>
<th>Employee Suggestion</th>
<th>Autonomous Maintenance</th>
<th>Power Distance</th>
<th>Individualism</th>
<th>Masculinity</th>
<th>Uncertainty Avoidance</th>
<th>Centralization of Authority</th>
<th>Cooperation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Group Problem Solving</td>
<td>0.628</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employee Suggestion</td>
<td></td>
<td>0.320</td>
<td>0.412</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Autonomous Maintenance</td>
<td></td>
<td></td>
<td></td>
<td>0.026</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Distance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.079</td>
<td>0.010</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individualism</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Masculinity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncertainty Avoidance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centralization of Authority</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooperation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process Emphasis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
We find that
- Cooperation and Uncertainty Avoidance significantly explain 28% of variability of Small Group Problem Solving
- Cooperation and Centralization of Authority significantly explain 25% of variability of Employee Suggestion
- Cooperation, Masculinity, Individualism, and Process Emphasis significantly explain 29% of variability of Autonomous Maintenance

The results of our analysis can be summarized as follows.

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>R²</th>
<th>Adjusted R²</th>
<th>F</th>
<th>Sig.</th>
<th>Independent Dependent Variables</th>
<th>Beta</th>
<th>T value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Group Problem Solving</td>
<td>0.284</td>
<td>0.278</td>
<td>46.517</td>
<td>.000</td>
<td>(Constant)</td>
<td>0.795</td>
<td>1.551</td>
<td>0.122</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cooperation</td>
<td>0.512</td>
<td>9.258</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Uncertainty Avoidance</td>
<td>-0.120</td>
<td>-2.168</td>
<td>0.031</td>
</tr>
<tr>
<td>Employee Suggestion</td>
<td>0.255</td>
<td>0.245</td>
<td>26.553</td>
<td>.000</td>
<td>(Constant)</td>
<td>3.789</td>
<td>6.232</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cooperation</td>
<td>0.297</td>
<td>5.031</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Centralization of Authority</td>
<td>-0.337</td>
<td>5.497</td>
<td>0.000</td>
</tr>
<tr>
<td>Autonomous Maintenance</td>
<td>0.295</td>
<td>0.283</td>
<td>27.70</td>
<td>.000</td>
<td>(Constant)</td>
<td>1.010</td>
<td>1.882</td>
<td>0.061</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cooperation</td>
<td>0.457</td>
<td>8.200</td>
<td>0.000</td>
</tr>
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**CONCLUSIONS**

National culture and organizational culture provide fruitful area for research on quality management. The first finding of this study is the influence of national culture on transformation of Kaizen practices. We find that the implementation of Kaizen practices associates with low power distance, female, and collectivism aspects. This finding is in line with previous quality management studies [1] [3] [9] [12]. Beside of this, our analysis proved that implementation of Kaizen practices associates with culture in low uncertainty avoidance. This can be explained that the cultures in low degree of uncertainty avoidance are open for new things and changes. Low uncertainty avoidance countries are more likely to stimulate innovations and emphasize new ideas. They are more flexible and more acting than reacting on changes occurring inside and outside of business. This finding suggests that Kaizen practices can be transferable to non-Japanese cultural environment. In addition to the national culture, our study indicates that the organization culture significantly influences the adoption of Kaizen practices. The biggest barrier to Kaizen success is the centralization of authority and lack of cross-functional cooperation. In order to increase the chances for successful Kaizen adoption, two aspects of organizational culture are required: power delegation and empowerment, and high cooperation between managers, workers, customers, and suppliers. The great influence of the national culture and organizational culture on Kaizen practices indicates that there is not a universal model for successful Kaizen transformation. Kaizen practices should be adapted to the local culture; in order have the highest probability of success.

**REFERENCES**


The 11th International DSI and the 16th APDSI Joint Meeting, Taipei, Taiwan, July 12 – 16, 2011, pp.580-586

APPENDIX

Centralization of Authority
1. Even small matters have to be referred to someone higher up for a final answer.
2. This plant is a good place for a person who likes to make his own decisions.
3. Any decision I make has to have my boss’s approval.
4. There can be little action taken here until a supervisor approves a decision.

Cooperation
1. We work as a partner with our suppliers, rather than having an adversarial relationship.
2. We encourage employees to work together to achieve common goals, rather than encourage competition among individuals.
3. We work as a partner with our customers.
4. We believe that cooperative relationships will lead to better performance than adversarial relationships.
5. We believe that the need for cooperative relationships extends to both employees and external partners.
6. We believe than an organization should work as a partner with its surrounding community.
7. Sometimes we encourage competition among employees, in order to improve their performance.

Process Emphasis
1. We believe that the process, rather than the people performing the process, is the source of most errors.
2. In our view, most problems result from the production system, rather than from individual employees.
3. In our view, the process is the entity that should be managed.
4. We believe that process improvements will result in greater quality improvement than human resource initiatives.
5. We think that most of our quality problems result from a lack of motivation.
6. Many of our quality problems result from employees who just don’t try very hard.

Small Group Problem Solving
1. During problem solving sessions, we make an effort to get all team members’ opinions and ideas before making a decision.
2. Our plant forms teams to solve problems.
3. In the past three years, many problems have been solved through small group sessions.
4. Problem solving teams have helped improve manufacturing processes at this plant.
5. Employee teams are encouraged to try to solve their own problems, as much as possible.
6. We don’t use problem solving teams much, in this plant.

Employee Suggestions
1. Management takes all product and process improvement suggestions seriously.
2. We are encouraged to make suggestions for improving performance at this plant.
3. Management tells us why our suggestions are implemented or not used.
4. Many useful suggestions are implemented at this plant.
5. My suggestions are never taken seriously around here.

Autonomous Maintenance
1. Cleaning of equipment by operators is critical to its performance.
2. Operators understand the cause and effect of equipment deterioration.
3. Basic cleaning and lubrication of equipment is done by operators.
4. Production leaders, rather than operators, inspect and monitor equipment performance.
5. Operators inspect and monitor the performance of their own equipment.
6. Operators are able to detect and treat abnormal operating conditions of their equipment.
A TECHNO-ECONOMIC PERSPECTIVE OF GREEN IT IMPLEMENTATION IN EUROPE AND THE US
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ABSTRACT
The present paper investigated the implementation of environmentally responsible IT measures in ten American and nine European organizations. The Green IT measures include the implementation of technologies as well as organizational and managerial actions that aim to reduce environmental impacts of IT use. These adjustments to organizational processes in addition to the infrastructure are “techno-economic” in nature. The term techno-economic denotes concurrent consideration of technological, social, and economic issues surrounding an innovation. We interviewed at least two executives in each of the organizations in our study to assess the extent of Green IT implementation. Based on the analysis of interview data, we conclude that the techno-economic adjustments were necessary for widespread implementation Green IT measures.

Keywords: Green IT, Data Center Management, Environmental Responsibility, Organizational Development, Corporate Strategy

INTRODUCTION
The present paper analyzes Green IT implementations in organizations from a ‘techno-economic’ perspective. The term techno economic, originating in sociology and evolutionary economics, posits that the study of certain technological changes must consider concomitant social and economic changes as well [11]. According to this perspective, the study of a technological change or innovation will result in a comprehensive understanding if the research focuses on the linkages among the technological, social and economic adjustments resulting from the implementation of the innovation. Therefore, the implementation of Green IT initiatives in organizations can be analyzed using the techno-economic perspective because environmentally responsible IT initiatives embody changes in organizational processes in addition to the physical IT infrastructure [19].

The present paper is organized as follows. A description of Green IT initiatives in organizations will be followed by a discussion of the techno-economic literature. A proposition on the relationship between Green IT and techno-economic considerations will be developed based on these discussions. The section on methodology will describe an empirical study to collect and analyze data to evaluate the proposition. Finally, the discussion and conclusions sections will provide the analysis of the collected data and directions for future research.

Green IT
Continued growth in the use of Information Technology (IT) for information processing by organizations has environmental consequences. As more and more paper based tasks migrate to electronic data processing, the demand for energy and material resources increases as well. In addition to information processing tasks related to data processing, pervasive use of IT in all facets of organizational operations (such as communication networks) requires further resources. Moreover, disposal of depreciated electronic equipment used in information processing tasks necessitates environmentally responsible handling processes. It is clear that as we continue to increasingly migrate toward a distributed, online, and electronic work environment, we affect the physical environment around us. Despite the significance of this issue, academic researchers in Information Systems (IS) have paid little or no attention to the relationship between IT use and environmental sustainability. IS practitioners, on the other hand, are very much aware of this issue [3]. Moreover, the US government also has recently paid attention to the environmental impacts of IT use as indicated by a recent
report from the Environmental Protection Agency report [20]. For the purposes of gauging environmental impacts, organizational activities that use IT can be very broadly categorized as: (1) data processing tasks performed by corporate data centers, and (2) all other non data center information processing tasks that require IT for support and execution. The issue of energy consumption by data centers has recently received the US Environmental Protection Agency’s (EPA) attention [20]. We will first present environmental sustainability issues relevant to data center operations followed by all other non-data center information processing tasks.

Many factors contribute to the growth in data center activities including the increased use of: electronic transactions, internet communications and entertainment, electronic medical records, satellite navigation, electronic shipment tracking, the internet to publish government documents, government regulations requiring digital records retention, digital provision of government services, high performance scientific computing, etc. A report published in August 2007 by the EPA in response to a request from Congress noted that the U.S. data centers are experiencing major growth through increasing demand for data processing and storage capacities. Data centers consumed 61 billion kilowatt-hours (kWh) in 2006 accounting for $4.5 billion in cost and 1.5 percent of total U.S. electricity consumption. The report noted that corporate and government data centers have adopted and continue to adopt technological measures to reduce energy consumption. Despite these efficiency trends, the EPA estimates that national energy consumption by data centers will most likely increase to more than 100 billion kWh by 2011 accounting for $7.4 billion.

In addition to the data centers, IT supports day to day operations of present day enterprises ranging from end user information processing tasks to supply chain activities. Thus far, the EPA has not assessed the environmental impact of non data center activities. However, IT as a whole leaves a carbon footprint that is a combination of centralized and non-centralized data centers and non data center activities. “When it comes to emissions, ICT is on a par with aviation…… Yet these numbers look less frightening if…… ICT’s ‘enabling effect’ is taken into consideration…..ICT could help to reduce emission in other industries by 7.8 billion tons by 2020, or five times ICT’s own footprint” [7].

Although academic researchers have only begun to address sustainability issues related to IT use [15] [21], a considerable body of research has developed around the relationship between environmental sustainability and corporate strategy [1] [2] [9] [14] [17] [18].

The Techno-economic Considerations

The distinction between infrastructure and techno-economic changes is discussed by Carlota Perez [16]. Adoption of Green IT initiatives engenders changes that include techno-economic as well as infrastructure adjustments. Techno-economic adjustments pertain to managerial and organizational processes of a firm while infrastructure adjustments address the potential of the current technological state of the firm to accommodate future technological transitions. Examples of techno-economic adjustments include organizational design issues such as changes in the level of formalization, decentralization and complexity, among others. For example, implementation of flexible telecommuting and reorganization of workforce require techno-economic adjustments. On the other hand, examples of infrastructure adjustments include changes in physical processes, methods, techniques, and equipments in order to implement Green IT measures.

Two concepts are central ideas in techno-economic considerations. These are the ‘Techno-Economic Network’ (TEN) and the ‘Techno-Economic Paradigm’ (TEP). Callon [4] [5] originally developed the concept of TEN which is rooted in the field of sociology. TEN integrates the role of dynamic relationships among various actors in the society and the flow of intermediaries in promoting a specific technological innovation. The concept of TEN views the interaction among the actors as a critical factor in promoting and implementing an innovation.

The concept of TEP, on the other hand, is rooted in the writings of evolutionary economists such as Perez [16] and Freeman [10]. TEP is concerned with explaining economic changes as a result of technological shifts. TEP analyzes the compatibility of the technological infrastructure with economic growth rate over the long run. As a specific technology evolves, the economic, social and institutional changes must be aligned to support the adoption of the technology. The focus of the TEP concept is on aligning organizational and economic linkages of a technology with its growth.

Based on the above discussion, we formulate the following proposition:

P1: The firms that include techno-economic considerations in the adoption of Green IT measures will be further along in their implementation efforts than the firms that do not include techno-economic considerations.

**RESEARCH METHODOLOGY**

We used a qualitative approach in our data gathering and analysis efforts. Qualitative methodology is appropriate for exploratory investigations [6] [12]. For analyzing the data, we used inductive analysis [2].

In order to investigate the TEN and TEP, we initially intensively interviewed eight Green IT evangelists who were based in the US and Europe. We identified them through internet based searches. The goals of our initial interviews were to: 1) construct a set of interview questions that would be useful for eliciting information from organizations that are implementing Green IT technologies and initiatives, and 2) identify appropriate executives in organizations who would
provide us with reliable information regarding environmental impacts of IT use and their organizational initiatives. Our interviews with the Evangelists helped us prepare twenty six interview questions for the Chief Information Officer (CIO) which we refined during our interviews. All eight Green IT evangelists opined that, in addition to the CIO, the executive in charge of facilities and physical plants would be the person we would need to interview in practitioner organizations to collect appropriate information regarding the management of environmental impacts of IT use. Following are the questions for the CIOs interviewed in this study which we modified while interviewing other executives in the organizations.

1. Tell us about your company: revenue, number of employees, size of IT (number of servers and employees), IT centralized/decentralized, CIO reporting to CEO/CFO, type of company?

2. Is there an environmental /sustainability action plan in your company? If yes, does this action plan include Green IT (GIT)?

3. Is there a sustainability manager or an equivalent in your company?

4. Is GIT a corporate issue or just an IT issue?

5. Is there a restructuring of capital costs and operating costs as a result of GIT? If yes, does the restructuring involve the CFO or only the IT department and facilities/operations department?

6. Do you have any policy to encourage GIT to your users? If yes, what are the policies?

7. What is the size of your data centers? ___ sq ft, How many? ___Mid Tier; ___ Enterprise

8. Does GIT influence your purchasing/procurement decisions (e.g., buy Energy Star)?

9. What metrics are being used to measure power consumption in data centers? Do you plan to use these metrics for benchmarking purpose?

10. Have you set specific targets for data centers to be achieved by your GIT initiatives?

11. Which of the following GIT measures have you adopted? We used the list of the measures compiled by Sayeed and Gill (2008).

12. Do you consider GIT in your evaluation of outsourcing/collocation facilities?

13. When and under what circumstances did you adopt the GIT measures above?

14. Has the EPA played any role in your GIT adoption?

15. Do you think GIT measures impact your company’s profitability/bottom line?

16. What are the broader organizational advantages of GIT beyond financial reasons?

17. Has GIT led to the redesign of your data centers or other physical facilities?

18. Did the implementation of GIT measures require or engender cooperation from other departments?

19. Has GIT influenced your human resource capabilities?

20. Does GIT have any impact on your firm’s reputation?

21. Do you seek a leadership position on GIT within your industry?

22. What are the organizational barriers or resistance to GIT?

23. How committed are your upper management to GIT?

24. What role do you see standards or regulations having on adoption of GIT (innovation)?

25. Are you aware of any incentives from Federal/State governments or public utilities encouraging GIT?

26. Can you tell us how your organization’s IT governance structure helps or hinders GIT? Any conflict with Sarbanes and Oxley Act?

Following our interviews with the Green IT evangelists, we contacted twenty organizations in the US. In ten of these organizations, we interviewed the CIO and the executive in charge of physical plants and operations. In three of these ten organizations, we also interviewed a third manager who was able to provide additional information regarding the data center operations and overall environmental initiatives. We did not include the remaining ten organizations in our data analysis of US organizations because six of these organizations declined our invitation altogether and we were able to interview the CIO only in the other four. Finally, we analyzed thirty one interviews in the US consisting of twenty three executives from ten practitioner organizations and eight Green IT evangelists from public and private sectors. All interviews were audio taped and transcribed. Moreover, both researchers took meticulous notes during the interviews. In general, each interview lasted from forty five to ninety minutes. We also consulted web sites of all the practitioner and evangelist organizations. In addition, we reviewed relevant documents and memos shared by the respondents. In Europe, we were able to interview at least two executives in each of the nine out of ten organizations we had approached.

Tables 1 and 2 display the profiles of the US and European organizations respectively.
Our goal was to classify practitioner reviews. The European organization which we resolved after a discussion. Following the three stages in the model are unfreezing, changing and refreezing.

The implementation of Green IT initiatives begins with the unfreezing stage. This is when the organizations become aware of the environmental impacts of their IT operations and a formal or informal plan to implement Green IT initiatives and technologies starts to emerge. The organization is gathering data and concurrently laying the foundation for a course of action to adopt Green IT measures at this stage. We observed that all ten US organizations in our study had reached this stage.

We analyzed the data iteratively following Bansal and Roth’s [2] approach to inductive analysis. Our goal was to classify the extent of Green IT implementation in each of the nineteen organizations. The US based co-authors individually read the transcripts of the thirty one interviews in the US in addition to their own notes taken during the interviews. The European co-authors used analogous analysis procedure. Based on Lewin’s [13] three stage model of organizational development, we individually classified the nineteen practitioner organizations based on their Green IT initiatives and then conferred on the classification. Our agreement level was very high because we differed on the classification of only one organization which we resolved after a discussion. Following is a discussion of Lewin’s three stage model.

We used a three stage model of organizational change to capture the extent of Green IT adoption in organizations. The three stages in the model are unfreezing, changing and refreezing.

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organizations transition to the changing state, they begin to implement Green IT measures. However, they also continue data gathering and enhancing their awareness of the environmental initiatives. Based on the results of their data gathering, they may need to realign their Green IT plans. This realignment and continued information search is reflected in feedback loop A. Of the ten US organizations, those labeled 3, 4, 5, 7 and 10 have reached this stage while 6, 8 and 9 have progressed further.

In the third stage—refreezing, most if not all of the planned Green IT initiatives have been implemented. However, further alignment of the initiatives and information gathering continues. Feedback loops B and C depict the continued data gathering and alignment of Green IT initiatives. US organizations labeled 6, 8 and 9 have reached the refreezing state and the feedback loops.

**FINDINGS**

US organizations 6 and 9 along with the European organization 3 demonstrate that they have completed all three phases and the feedback loops of the Green IT implementation model. US organization 8 and European organization 4 have completed all three phases but have not completed all the feedback loops. Following is a discussion of the US organizations 6, 8 and 9 followed by that of the European organizations 3 and 4.

**US Organizations 6, 8 and 9**

US organizations 6, 8 and 9 were further ahead, of the ten US organizations described above, in terms of their Green IT implementation practices.

Practitioner Organization 6 was developing a sustainability plan for the entire company. Moreover, they had designated a manager in charge of the initiative. The Green effort was mainly a worldwide corporate effort that was focused on the efficiency of facility utilization and had an acceptable ROI of two to three years. Data center efficiency, however, was on top of the list. Even though the company had implemented a measurement for data center efficiency of BTU/Sq. Ft., they had not set any goals. With respect to E-Waste, it was clear the company had already achieved refreezing. They had implemented an audit practice to account for proper disposal of all E-Waste. The company had applied and received local county Green certification and they had incorporated the LEED Green Building Rating System into their new facility design standards. In general, the company had implemented several infrastructure and techno-economic changes in data centers and the entire organization. Additionally, they were monitoring the impact of these changes such as energy efficiency in the data centers due to Virtualization and other infrastructure improvements. Our interview also revealed that the company had implemented feedback loop A for E-Waste, and feedback loops B and C for space and power efficiency utilization.

Practitioner Organization 8 had appointed a Director of Sustainability and was actively engaged in initiatives in the IT department, the data centers and the end user environment. The Green initiatives were undertaken with top level executive involvement and commitment. The company was using Green in their marketing activities. Following is an excerpt from the software maker’s web site about a new product named Green Snapshot.

“(Name of the company) Green Snapshot provides you recommendations on how to save money by going Greener. It’s all based on your (name of the software) data, so there’s no extra work for you! With (name of the company) Green Snapshot, it’s easy to:

- View a chart that estimates your biggest categories of carbon emissions based on your (software name) expenses with just a few clicks.
- Scroll through recommendations to help your business go Greener and save money. Each idea is clearly written, provides a description of how to take the action and offers links to key resources.
- Share your progress with your customers – give your Green customers a reason to keep coming back!”

In the unfreezing phase they had conducted surveys and measurements (using outside consultants) to determine areas of Green improvements in the entire company. They had also conducted a study to determine the company’s carbon footprint which was broken down to: 51% - electricity use, 20% - commuting, 20% - direct marketing, and 8% travel. A steering committee had set goals for carbon footprint reductions and delineated a course of action to make changes in appropriate corporate policies to implement Green initiatives. They had adopted all the LEED standards for new building construction. All of the infrastructure and techno-economic initiatives that were adopted were in the refreezing stage. They were developing software tools for their customers to set goals and monitor their own Green initiatives. The company desired to become a “good corporate citizen” and as part of refreezing they were setting up education programs for their employees. Employee participation was part of their feedback loops A and B. However, we did not detect a feedback loop C where their original plans were being modified as a result of their implementation of Green IT initiatives.

A corporation wide Green strategy was in place in Practitioner Organization 9 with comprehensive measurement of their Green initiatives. Following is an excerpt from the company’s web site.

“……we share in the global responsibility for protecting and preserving our environment today and for future generations by not only creating energy efficient products, but also by practicing good environmental stewardship.

Our approach to fighting growing power consumption is simple: subtract machines and disks from the power equation by using storage more efficiently. This strategy has many corollary benefits: it lowers complexity, people costs, support and service costs, while improving network efficiency and performance.”

The company was the most advanced company according to the three stage model that we encountered among the ten practitioner organizations. They not only had fulfilled the planning, action, and results corresponding to unfreezing, changing, and refreezing, they also had in place all three
feedback loops: A, B, and C. The VP of Physical Plants stated that their measured Power Usage Effectiveness (PUE) rating was at 1.37 with a goal of achieving a rating of 1.2. The CIO commented that the main driver for Green is “capitalism and not citizenship.” With Green they felt they could reduce the cost of ownership and hence offer delivery services to their customers at affordable prices. The VP of Physical Plants emphasized that “Being Green was not a direct objective but rather a tactic to increase returns to their shareholders.” This company was incorporating Green IT features in their product innovation process by adding environmentally beneficial features to their data storage products as well as their software.

European Organizations 3 and 4
European organizations 3 and 4 had implemented most of the Green IT initiatives. European organization 3 was a subsidiary of a multinational corporation. The utility company had a sustainability plan called “Health, Safety and Environment” that dealt with power consumption and CO2 footprint. The company joined the “World Community Grid” that allows sharing of processing power accumulated during non peak periods. The company also adopted initiatives such as video conferencing in order to reduce the footprint resulting from personnel travel. Additionally, a program to stimulate green behavior among its customers was operational. The green initiatives encompassed all three feedback loops: A, B, and C. The firm bought Energy Star machines and implemented a check list for regulating future purchases, giving different weights to different factors according to their sourcing strategy. Furthermore, the organization was building a new data center designed to be one of the most modern and energy efficient in Italy. The CIO commented:

“To measure our consumption we use the Power Usage Effectiveness (PUE), calculating an annual average of our measures. The new data center will have an annual PUE lower than 1.2: this is a significant goal, if you consider that the most efficient data center in Italy currently has a PUE higher than 1.75.”

Organization 4 was a multinational corporation with strong green focus: the company had an European sustainability plan and Green IT is an important component of this plan. Green IT was a part of the “Health Safety and Environment Impact Procedures” (HSE) of this company: every decision was made considering the environment and safety impact. They had three metrics to measure the effectiveness of their Green IT initiatives: percentage of server utilization, number of virtualized servers and power saving. The interview data did not indicate the presence of feedback loops B and C in this organization. The firm’s top management was committed about Green IT policy. Following are some comments from CIO and VP Plants.

“Green IT belongs to a general corporate philosophy of environmental attention. Our green focus impacted various managerial choices.”

“Now we are developing the biggest Italian pharmaceutical plant and it will be entirely paperless. The new refrigeration plant that we are going to setup has a zero CO2 footprint. Furthermore, we are thinking about a cloud computing solution for some services.”

“Now our IT is centralized in the UK and we have an European and Italian policy for energy saving. This allowed us to get a 70% energy saving. The metrics we are using to measure our green IT initiatives are: percentage of server utilization, number of virtualized servers and power saving.”

DISCUSSION AND CONCLUSIONS

Several insights can be drawn from the findings of the present investigation. First, the Green IT evangelists and their efforts to promote adoption of environmentally responsible IT measures indicate the existence of the TEN. The evangelists included public and private individuals who are engaged in promoting Green IT because of their personal gain or institutional affiliation.

Second, the organizations in the US as well as in Europe that are integrating techno-economic considerations in their Green IT implementation are further along than organizations who are viewing Green IT as an infrastructural issue only. In order for a widespread and effective implementation of Green IT, organizations need to align their organizational processes such as adopting LEED standards and video conferencing to reduce travel.

Third, techno-economic considerations necessitate data collection of various organizational activities. The more advanced adopters of Green IT initiatives collected data of carbon footprints beyond electricity consumption. These organizations view Green IT as a market force that can be harnessed to enhance their strategic position in addition to being a vehicle to respond to the societal need to be environmentally responsible.

Finally, future research should extend the qualitative research approach to quantitative techniques that would lead to conclusions with the ability to generalize the findings more widely than the current research.

REFERENCES


A NINE-COMPONENT DECOMPOSITION OF TEN WORLD REGIONS OVER FOUR DECADES OF CO₂ EMISSION CHANGE USING LATENT VARIABLE DEA TECHNOLOGY

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ABSTRACT

A new methodology for the simultaneous reduction of input and output variables is developed as an environmental DEA production oriented technology. The Latent Variable specified facilitates the manipulation of both undesirable inputs and outputs in an oriented radial efficiency model. Using this method carbon emission change over four decades is decomposed into nine components for ten world regions thereby correcting and augmenting previous studies. A momentum indicator for carbon reduction and energy consumption reduction are also derived using the Malmquist Index for frontier shift and innovation as well as their counterparts for catch-up and recovery.

Keywords: Malmquist Index, Data Envelopment Analysis, Decomposition, Catch Up, Frontier Shift

INTRODUCTION

The impact of CO₂ emissions on global warming and climate change will likely cost tens of thousands of species their existence on this planet over the next twenty to fifty years. [1]. The human costs may also be staggering in terms of loss of life or employment. A large part of our species may also be included on the ‘extinct list.’ Sadly the biggest players do not take environmental devastation seriously enough despite more than four decades of warnings from the scientific community. Therefore, it is with a sense of urgency that we propose an improved methodology for assessing aggregate CO₂ emissions reductions.

This paper identifies the relationship between undesirable outputs and respective input variables in the nonparametric linear programming environment and develops a powerful new methodology for dealing with such ‘undesirable variables.’ Typically in data envelopment analysis, DEA, or nonparametric LPs we find two approaches to reducing undesirable variables. In the non-oriented additive approach we find undesired outputs are subtracted as a form of over-production slack [2]. Other authors use a radial approach that directly reduces the undesirable output as if it were an output [3]. Both approaches are questionable in view of the production set assumptions.

Our alternative is to minimize the appropriate input variable and derive what we term a Latent Variable that sympathetically reduces the appropriate undesirable output. In this way both the reduction variables remain true to the production assumptions and are highly correlated to each other, which accurately reflect the DMU’s characteristics. This method can be used in many forms, but the input form will be demonstrated here in our first application example, which decomposes the change of aggregate CO₂ emissions at the world regional level, and then in our comprehensive second application example, which analyzes the characteristics of aggregate CO₂ emissions change for 140 individual countries. Our analyse tools will not only include our the Latent Variable approach for determining the reduction coefficients, but will also include a nine component decomposition model used to derive the momentum for both CO₂ emissions and energy consumption reductions over the past four decades.

This article will first examine the production set and its weak disposability assumptions in the literature. Then, we introduce our Latent Variable DEA technology and compare it to the alternatives. Next, we extend the seven-component decomposition model in the literature to a nine-component model to capture greater transparency in its usage. Finally, we demonstrate the efficacy of our models by deriving reduction momentum in two extensive application studies on CO₂ emissions over the last four decades.

Two Important Caveats

First, GDP is not necessarily always desirable and it has been shown to be a poor indicator of social progress. [4] It should be reduced in importance in a socio-economic context such as this, but a decomposition of GDP into its desirable and undesirable effects is outside the scope of this study. For this reason we have used GDP per capita tying it to population as an input, but not making the common assumption that this in anyway reflects the real income of the people at large. Such assumptions are doubly false when taken in the context of rising Gini coefficients such as in the United States, that is, in countries where the income-disparity gap continues to widen.

Second, the null-joint assumption widely used in DEA means that all production processes are polluting, and conversely that the only way to stop pollution is to stop production. This can be used, and is used, as a justification to continue the use of fossil fuels as the only ‘large scale viable’ energy source, albeit with deadly consequences for the environment. Yet in light of the new technology for Enhanced Geothermal Systems, EGS, oil is NOT the only ‘real’ alternative! EGS electricity production is not only virtually CO₂ emissions free, but extremely cheap, and relatively ‘lo-tech’ with no future liabilities such as nuclear waste, radioactive leakage, or catastrophic oil spills. EGS is easily scalable to any location since subterranean heat is ubiquitous on the planet. Its application in the USA alone, according to the landmark 2006 MIT study [5], could
support energy consumption at current US levels for some 13,000 years! Hence, we only tacitly make the ‘null joint’ assumption in hopes that this paper and others like it can begin to address larger, more pressing issues from a realistic rather than status quo perspective.

LATENT VARIABLE MODEL ASSUMPTIONS AND SPECIFICATION

Production Technology

We consider an aggregate production process across regions and countries with energy consumption (X) as a single input, gross domestic product (Y) as a desirable output and energy-related CO₂ emissions (U) as an undesirable output. Such an aggregated production technology can be described as 

\[ T = \{(X,Y,U): X \text{ produces } (Y,U)\} \]

Färe, Grosskopf, Lovell, & Pasurka [6] introduced two assumptions to model aggregate desirable and undesirable outputs as follows:

Outputs are weakly disposable, that is, if \((X,Y,U) \in T\) and \(0 < \theta < 1\), then \((\theta X, \theta Y, \theta U) \in T\). Desirable and undesirable outputs are null-joint, that is, if \((X,Y,U) \in T\) and \(Y = 0\), then \(U = 0\).

A polluting technology, \(T\), can be formulated as an environmental DEA technology by constructing piecewise linear combinations of the observed data. This non-parametric framework is organized according to decision-making units, DMUs can be companies or countries, such that each triple \((X_j, Y_j, U_j)\) captures the observed data for each entity \(j\). In general, we can capture this production set more fully if we include a convexity constraint, \(\sum_j z_j = 1\), that give variable returns to scale, VRS, rather than the commonly used CRS technologies [7], which assigns constant returns to each DMU. Variable returns to scale are especially useful where the observed data is widely varied and has not been normalized [2], as in world economic data. Equation 1 states the possible linear combinations of a VRS production set in its familiar DEA form, with \(0 \leq \lambda \leq 1\) which represents the possible reduction of undesirable outputs by any means.

\[
T = \{ (X,Y,U) : \textrm{such that} \}
\]

\[
\sum_j z_j X_j \leq X
\]

\[
\sum_j z_j Y_j \geq Y
\]

\[
\sum_j z_j U_j = \lambda U
\]

\[
\sum_j z_j = 1 \quad j = 1,2,..., J
\]

This production set, \(T\), is a BCC DEA model [8] exhibiting variable returns to scale, VRS, much like the Environmental Performance Index EPI framework developed by Zhou et al. (2008). We extend this VRS framework to calculate our reduction coefficients on \(X\) and \(U\). Many other energy and environmental studies have investigated the concept of environmental DEA technologies, its application and assumptions. For a survey of energy and environmental DEA approaches see [9]. Relevant section are also included in [10] and [11].

Decomposition Method

We use the decomposition method devised by Zhou & Ang [12], but refrain from using Shephard Distances. Instead, we use their equivalent reciprocals: the DEA efficiency scores, called herein reduction coefficients [13]. We also simplify the calculation of the decomposition by using a single integrated VRS DEA model rather than two CRS formulations. This will give us a better match to the variability in the data while making our reduction variables highly correlated to the characteristics of production for each separate DMU. The development of the CO₂ emissions decomposition follows.

Overall, we wish to decompose the change in aggregate CO₂ emissions, \(U\), into its components using only GDP, \(Y\), and Energy Consumption, \(X\). Starting with its essential form, the change in aggregate CO₂ emissions from period \(K\) to period \(L\) is equal to the product of the change in Carbon Factor \(\left(\frac{U_j}{X_j}\right)_L\), the change in Energy Intensity \(\left(\frac{X_j}{Y_j}\right)_L\), and the change in GDP. This can be expressed in its multiplicative form for each DMU \(j\) as follows:

\[
D_j = \left(\frac{U_j}{U_j^K}\right) \cdot \left(\frac{X_j}{X_j^K}\right) \cdot \left(\frac{Y_j}{Y_j^K}\right)
\]

(2)

The reference periods \(K\) or \(L\) in Equation 2 will be denoted as a superscript on the reduction coefficients from the estimation models, \(\alpha\) for energy reduction and \(\lambda\) for carbon reduction. The variables \(X\), \(Y\) and \(U\) carry the aggregate values to be compared and each is divided by the population of the DMU in that period, that is per capita GDP, etc. Hence, the production characteristics for each DMU will remain unchanged, but population as a non-reducible input variable will impact the efficiency of DMUs across the frontier.

First, Carbon Factor and Energy Intensity are inflated by their relative inefficiency factors, their reduction coefficients, with reference to the initial period, \(K\). For example, using the production technology of period \(K\) as...
reference, the functional representation of the reduction coefficient for carbon emissions is $\lambda^k_j(X^j, Y^j, U^j)$ where the objective values are from period L. That is, the production set of period L is evaluated using the technological efficiency of period K. Then the inverse deflators are added after the GDP change term to balance our expression. This interpretation is given in Equation 3.

$$D_j = \left\{ \begin{aligned} & \frac{U^j}{X^j} \left( \frac{\lambda^k_j(X^j, Y^j, U^j)}{\lambda^k_j(U^j)} \right)^{\frac{1}{2}} \frac{X^j}{Y^j} \left( \frac{\alpha^k_j(X^j, Y^j, U^j)}{\alpha^k_j(U^j)} \right)^{\frac{1}{2}} \\ & \frac{Y^j}{X^j} \left( \frac{\lambda^k_j(U^j)}{\lambda^k_j} \right)^{\frac{1}{2}} \frac{X^j}{Y^j} \left( \frac{\alpha^k_j(X^j, Y^j, U^j)}{\alpha^k_j(U^j)} \right)^{\frac{1}{2}} \end{aligned} \right. \tag{3}$$

We can state this more concisely by simplifying the function $\lambda^k_j(X^j, Y^j, U^j)$ to $\lambda^k_j(U^j)$ since the performance measure $\lambda$ applies only to CO$_2$ emissions $U$. Similarly, $\alpha^k_j(X^j)$ is the performance measure for energy consumption in period L as calculated with reference to the technology of period K. Hence Equation 3 can be re-stated as Equation 4:

$$D_j = \left\{ \begin{aligned} & \frac{U^j}{X^j} \left( \frac{\lambda^k_j(U^j)}{\lambda^k_j} \right)^{\frac{1}{2}} \frac{X^j}{Y^j} \left( \frac{\alpha^k_j(X^j)}{\alpha^k_j(U^j)} \right)^{\frac{1}{2}} \\ & \frac{Y^j}{X^j} \left( \frac{\lambda^k_j(U^j)}{\lambda^k_j} \right)^{\frac{1}{2}} \frac{X^j}{Y^j} \left( \frac{\alpha^k_j(X^j)}{\alpha^k_j(U^j)} \right)^{\frac{1}{2}} \end{aligned} \right. \tag{4}$$

In first and second factors above, $\lambda$ and $\alpha$ act to inflate the Carbon Factor or Energy Intensity of their time periods in proportion to the inefficiencies of the DMU under consideration since both $\lambda$ and $\alpha$ range between zero and one. This assigns more weight to the objectives as inefficiency increases in proportion to technical efficiency. Hence, these factors are called the change in Potential Carbon Factor PCFCH and the Potential Energy Intensity Change PEICH, respectively. The third factor shows the GDP change, while the last two are the first terms in respective Malmquist Productivity Index Numbers, which gives the change in Total Factor Productivity. These indices will evolve into measures for CO$_2$ Emissions Performance CEPCH, and Energy Usage Performance EUPCH.

For a DMU on the efficiency frontier, both $\lambda$ and $\alpha$ become 1 and the analysis reduces to its basic expression. By taking the geometric mean of the reduction coefficients for each reference period, we neutralize the arbitrary effects of choosing one reference technology over another. This process also supplies the complementary terms for the Malmquist Productivity Indices. This is the five-component decomposition shown in Equation 5.

$$D_j = \left\{ \begin{aligned} & \frac{U^j}{X^j} \left( \frac{\lambda^k_j(U^j)}{\lambda^k_j} \right)^{\frac{1}{2}} \frac{X^j}{Y^j} \left( \frac{\alpha^k_j(X^j)}{\alpha^k_j(U^j)} \right)^{\frac{1}{2}} \\ & \frac{Y^j}{X^j} \left( \frac{\lambda^k_j(U^j)}{\lambda^k_j} \right)^{\frac{1}{2}} \frac{X^j}{Y^j} \left( \frac{\alpha^k_j(X^j)}{\alpha^k_j(U^j)} \right)^{\frac{1}{2}} \\ & \frac{Y^j}{X^j} \left( \frac{\lambda^k_j(U^j)}{\lambda^k_j} \right)^{\frac{1}{2}} \frac{X^j}{Y^j} \left( \frac{\alpha^k_j(X^j)}{\alpha^k_j(U^j)} \right)^{\frac{1}{2}} \end{aligned} \right. \tag{5}$$

The last two terms are Malmquist Indices used in the panel data to compare changes in Total Factor Productivity, TFP, between DMUs. Malmquist Productivity Index [14] are used to decompose TFP into a technology ‘catch up / recovery’ component and a ‘frontier shift /innovation’ component. Now the change in CO$_2$ Emissions Performance CEPCH and Energy Usage Performance EUPCH can be decomposed into their effects as in Equation 6:

$$\text{CEPCH}_j = \left( \frac{\lambda^k_j(U^j)}{\lambda^k_j(U^j)} \right)^{\frac{1}{2}} \left( \frac{\alpha^k_j(X^j)}{\alpha^k_j(X^j)} \right)^{\frac{1}{2}} = \text{CEEFCH} + \text{CATECH}_j \tag{6}$$

$$\text{EUPCH}_j = \left( \frac{\alpha^k_j(X^j)}{\alpha^k_j(X^j)} \right)^{\frac{1}{2}} \left( \frac{\alpha^k_j(Y^j)}{\alpha^k_j(Y^j)} \right)^{\frac{1}{2}} = \text{EUEFCH} + \text{ESTECH}_j \tag{6}$$

The change in CO$_2$ Emissions Performance, CEPCH, on the production side of CO$_2$ emissions is decomposed into a “catching up effect” called Carbon Emissions Technical Efficiency Change, CEEFCH, a ‘frontier shift’ due to the use of Carbon Abatement Technology, CATECH. The change in Energy Usage Performance, EUPCH, on the consumption side of CO$_2$ emissions is decomposed into a “catching up effect” called Energy Usage Technical Efficiency Change, EUEFCH, and a ‘frontier shift’ due to the use of Energy Savings Technology, ESTECH. This completes the classic seven-component decomposition of CO$_2$ emissions change presented in Equation 7.
The Nine-Component Decomposition splits the Potential Carbon Factor and Potential Energy Intensity into a more transparent form: Carbon Factor and Energy Intensity multiplied by their respective inverse Total Factor Productivity indices. The inverse terms of MI balance the products of CEEFCH, CATECH, and EUEFCH, ESTECH. Hence, we have used both aspects of the Malmquist Productivity Index in our extended Nine-Component Decomposition. More important, however, is that Carbon Factor and Energy Intensity are readily apparent. On the one hand, since GDP part of Energy Intensity its effect is more apparent when separated from Total Factor Productivity. Carbon Factor, on the other hand, is perhaps the most important component of CO₂ emissions change.

If we consider a Cartesian plane with energy consumption on the abscissa and CO₂ emissions on the ordinate, then the Carbon Factor is the slope of the efficiency frontier. For effective emissions reduction we need both a reduction of CO₂ emissions, which will rotate the radial component of the frontier counter clockwise about the origin, and we need a reduction of energy consumption, which implies that the frontier must shift to the left. The Carbon Factor incorporates both aspects of this change. Hence, we propose the following Nine-Component Decomposition as a more useful tool for the analysis of CO₂ emissions change. It is shown here in its complete and its concise form in Equations 9 and 10 respectively.

\[
D_j = \frac{U_j}{U_j^F} = \left( \frac{\frac{U^L_j}{U^L_j^F} \left( \frac{\alpha^k_j (X_j^L) \alpha^k_j (X_j^F)}{\alpha^k_j (X_j^L) \alpha^k_j (X_j^F)} \right)^{\frac{1}{2}}}{\frac{1}{X_j^L}} \right) = \frac{\frac{X_j}{X_j^F} \left( \frac{\alpha^k_j (X_j^L) \alpha^k_j (X_j^F)}{\alpha^k_j (X_j^L) \alpha^k_j (X_j^F)} \right)^{\frac{1}{2}}}{\frac{1}{Y_j^L}} \right)
\]

(7)

Or more concisely:

\[
D_j = \frac{U_j}{U_j^F} = PCFCH_j \cdot PEICHE_j \cdot GDPCH_j
\]

(8)

\[
\text{CEEFCH}_j \cdot \text{CATECH}_j \cdot \text{EUEFCH}_j \cdot \text{ESTECH}_j
\]

It can now be noted that the Nine-Component Decomposition is a significant improvement over its predecessor since the Potential Carbon Factor and Potential Energy Intensity can now be shown to be ambiguous in their meaning. In the previous study they were assumed to show improvement if their values were less than one. Yet, if the reciprocal of the TPF is less than one it indicates factor productivity has declined. However, this decline could be disguised in the Potential Carbon Factor depending on how significantly the actual Carbon Factor improved. This would make the direction of movement of PCFCH indeterminate, and likewise PEICHS movement could be counter-indicative of the real changes involved. Hence, our Nine Components using Carbon Factor and Energy Intensity multiplied by their respective inverse Total Factor Productivity indices are a more transparent form revealing the potential contrary motion of its factors. The ambiguity of PCFCH and EIFCH is demonstrated in logic of Equation 11.

\[
\text{CFCH}_j \cdot \frac{1}{\text{TPF}_j} \rightarrow \text{CFCH}_j \cdot \frac{1}{\text{MI}_j} \uparrow \rightarrow \text{PCFCH}_j \downarrow
\]

where CF and MI_c < 1 for improvement

\[
\text{EICH}_j \cdot \frac{1}{\text{TPF}_j} \rightarrow \text{EICH}_j \cdot \frac{1}{\text{MI}_j} \uparrow \rightarrow \text{EIFCH}_j \downarrow
\]

where EI and MI_e < 1 for improvement

(11)

The Reduction Momentum Index

From the nine-component scenario we find that Carbon Factor, CFCH, Carbon Emissions Efficiency, CEEFCH, and Carbon Abatement Technology Shift, CATECH, are improving when their ratios are less than one. These three ratios, when inverted, can give a positive indication of the amount of progress or momentum for carbon reduction for any particular DMU. Using their geometric mean as shown below we can combine the three. Similarly, the momentum for energy consumption reduction can be constructed using
the inverted ratios for Energy Intensity Change, EICH, Energy Usage Technical Efficiency Change, EUFCH, and Energy Savings Technology, ESTECH.

Hence, our nine-component decomposition gives two indicators for reduction momentum: one for carbon emissions, one for energy consumption. This makes effective use of our decomposition in understandable terms that incorporate the desirable aspects of the Malquist Productivity Index, efficiency and technology shifts over successive periods, with the main indicators of emission change. The momentum equations are shown in 12.

\[
\text{MV}_c = \left( \text{CFCH}, [\text{CUEFCH}, \text{CATECH}] \right) \gamma_c
\]

\[
\text{MV}_e = \left( \text{EICH}, [\text{EUEFCH}, \text{ESTECH}] \right) \gamma_e
\]

\[(12)\]

**THE LATENT VARIABLE ESTIMATION MODEL**

This section develops the Latent Variable estimation model as it arises from problems in the literature.

**Environmental DEA Technologies**

Environmental DEA technologies have been widely studied in the literature. Most previous environmental DEA technologies have focused on constant returns to scale when, in fact, most DMUs have some inefficiency relative to other related firms and therefore do not fall on the CRS frontier [15]. Cooper, Seiford, & Tone state that the VRS frontier accommodates widely diverse data sets that have not been normalized [16]. More recent authors therefore have expanded their scope.

Of late, pure and mixed environmental indices have been developed by Zhou, Ang, & Poh [17] to analyze CO\(_2\) emissions and to facilitate their decomposition. These so-called pure technologies depend on a radial input model to make a single reduction: applied to the undesirable output variable. Three versions of this model emphasize three different returns to scale: constant, non-increasing and variable, called PEI\(_1\), PEI\(_2\), and PEI\(_3\), respectively. PEI\(_1\) is shown in Equation 13. Using PEI\(_1\), they then derive a Mixed Environmental Index by adjusting both the desirable and undesirable outputs in a VRS EPI, Environmental Performance Index. This model had the advantage of adjusting itself to the return scale by virtue of its \(\beta\) coefficient. Hence, it was not purely variable returns to scale, but after extensive testing we found that the \(\beta\) coefficient tends to increase inputs in several cases, thus negating its advantages and also violating the assumptions of the production set.

The inherent problem is that an output variable cannot be directly minimized in an input oriented radial LP because it runs contrary to the natural production process. Conversely, inputs cannot be directly maximized in a radial output model. Zhu states this fact rather bluntly in the literature and concentrates his efforts on developing a non-oriented additive model to reduce undesirable outputs[2]. To make this perfectly clear consider, for example, that we reduce undesirable CO\(_2\) emissions without considering how these emissions arise or how they may be abated after the fact of production. In the first case, we violate the production process by reducing an output directly while keeping input levels fixed. While it could be argued that this procedure will give us the after production emission slack consumed by abatement technology, this leads to the second case. How can we separate the effects of carbon abatement technology from that of improved input factor efficiency by simply reducing CO\(_2\) emission levels without the appropriate reductions of input factors that are directly responsible for emissions output? Separability is the issue and recognized by many authors [16].

A third problem deals with assigning scale efficiency to a DMU. To estimate scale efficiency both the CRS and the VRS frontiers must be calculated by using a standard input minimization model. A maximized output model could also be used, but the results would be the same since output maximization coefficients are the simple reciprocals of their minimized counterparts. So if we minimize an output using CRS, what standard can be used to evaluate scale efficiency? Using its correct counterpart, a minimized input using VRS, will lead to an erroneous result obviously.

\[
\text{PEI}_1 = \text{CRS Min } \lambda : \text{such that}
\]

\[
\sum_{j} z_{j} x'_{j} \leq x'_{j0}, \quad p = 1, 2, ..., P
\]

\[
\sum_{j} z_{j} y'_{j} \geq y'_{j0}, \quad q = 1, 2, ..., Q
\]

\[
\sum_{j} z_{j} \mu'_{j} = \lambda u'_{j0}, \quad r = 1, 2, ..., R
\]

\[
z_{j} \geq 0, \quad j = 1, 2, ..., J, t = K, M
\]

(13)

We can see that Zhou & Ang struggled with these questions in deriving their estimation model for the decomposition of CO\(_2\) emissions change. They used the following two CRS models for their decomposition of CO\(_2\) emissions change, which we call here the double CCR model. One model was used for each reduction coefficient necessary in the decomposition: Equation13 for Carbon reduction and Equation14 for Energy reduction.
Abraham Bretholt & Jeh-Nan Pan

**CRS Min \( \alpha \):** such that

\[
\sum_{j=1}^{J} z_j x_{pj} \leq \alpha x_{p0} \quad p = 1, 2, \ldots, P
\]

\[
\sum_{j=1}^{J} z_j y_{qj} \geq y_{q0} \quad q = 1, 2, \ldots, Q
\]

\[
\sum_{j=1}^{J} z_j u_{rj} = u_{r0} \quad r = 1, 2, \ldots, R
\]

\[z_j \geq 0, \quad j = 1, 2, \ldots, J, t = K, M\]

**Derivation and Correlation of the Latent Variable**

An interesting consequence was gleaned from running input models that minimize outputs such as PEI; above: a sympathetic reduction of inputs is achieved due to the inequality in the input constraint. That is, the input objective will be held fixed or reduced when the objective of the minimization is an equality. Hence, we noticed that as CO\(_2\) emissions were reduced in PEI\(_1\), energy consumption levels were also sympathetically adjusted relative to the frontier. The ratio of this reduced input to its original value is what we now call the Latent Variable, LV. Though this is no justification for the direct minimization of an output variable, it helped us to resolve all of the foregoing problems regarding undesirable outputs, and more.

When minimizing an input variable such as Energy Consumption, the Latent Variable preserves the production process by sympathetically reducing an output such as CO\(_2\) Emissions. This immediate resolves the production process problem while integrating both reduction variables into one model. Both MEI and the double CCR model tried to accomplish this but failed, and both violated the production assumptions. These variables are highly correlated as would be expected from the same production process; variable correlation between our model and theirs is shown in Table 1.

**Table 1 Reduction Variable Correlation between Models**

<table>
<thead>
<tr>
<th>Correlation of Variables</th>
<th>2002</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double CCR</td>
<td>-0.105</td>
<td>0.183</td>
</tr>
<tr>
<td>Integrated LV</td>
<td>0.859</td>
<td>0.857</td>
</tr>
</tbody>
</table>

**DECOMPOSITION APPLICATION STUDIES USING THE LATENT VARIABLE TECHNOLOGY**

**Data Set**

The data is from Key World Energy Statistics [18] longitudinal panel data from 1971 to 2007. Total primary energy supply is in Mtoe denoted as input \(X\); gross domestic product GDP (in billion US$ PPP) is denoted \(Y\) as desirable output; and CO\(_2\) emissions (in million tonnes or Mt) is denoted as undesirable output \(U\). The variables \(X, Y\) and \(U\) carry the aggregate values to be compared and each is divided by the population of the DMU in that period, that is per capita GDP, etc. Hence, the production characteristics for each DMU will remain unchanged, but population as a non-reducible input variable will impact the efficiency of DMUs across the frontier.

Four overlapping decades were chosen plus the latest two years of data to show the momentum for reduction of both energy consumption and CO\(_2\) emissions. In the first study, ten regions were chosen to comply with the degrees of freedom rule, which requires three times the number of DMUs as inputs and outputs. Previous studies that include only eight regions violate this basic linear programming rule [12].

Also, scale efficiencies for both variables can be achieved by running the LV model as either VRS or CRS. Both scale efficiencies are meaningful, as well, not just the one derived from the minimized input coefficient.

**CRS LV Min \( \alpha \):** such that

\[
\sum_{j=1}^{J} z_j x_{pj} = \alpha x_{p0} \quad p = 1, 2, \ldots, P
\]

\[
\sum_{j=1}^{J} z_j y_{qj} \geq y_{q0} \quad q = 1, 2, \ldots, Q
\]

\[
\sum_{j=1}^{J} z_j u_{rj} = u_{r0} \quad r = 1, 2, \ldots, R
\]

\[z_j \geq 0, \quad j = 1, 2, \ldots, J, t = K, M\]

\[
\sum_{j=1}^{J} z_j = 1 \quad j = 1, 2, \ldots, J
\]

\[z_j \geq 0 \quad t = K, M\]

\[0 \leq \lambda = z_j u_{rj}/u_{r0} \leq 1\]

Above we characterize the CRS Latent Variable Model used to calculate Technical Efficiency for Scale Efficiency and below its counterpart used for Pure Technical Efficiency, the VRS Latent Variable Model.

**VRS LV Min \( \alpha \):** such that

\[
\sum_{j=1}^{J} z_j x_{pj} = \alpha x_{p0} \quad p = 1, 2, \ldots, P
\]

\[
\sum_{j=1}^{J} z_j y_{qj} \geq y_{q0} \quad q = 1, 2, \ldots, Q
\]

\[
\sum_{j=1}^{J} z_j u_{rj} \leq u_{r0} \quad r = 1, 2, \ldots, R
\]

\[z_j \geq 0 \quad j = 1, 2, \ldots, J
\]

\[z_j \geq 0 \quad t = K, M\]

\[0 \leq \lambda = z_j u_{rj}/u_{r0} \leq 1\]

Notice that the Latent Variable in Equations 15 and 16 is achieved by the inequality on the undesirable output and the equality on the minimized input. But this technology can be extended to single or multiple outputs and inputs, desirable or otherwise. We hope this environmental DEA technology will prove to be a lasting contribution to non-parametric research.

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Ten Region Study in the Context of an Earlier Study

First, Table 2 updates the previous 2001-2002 to 2007-2008. Second, this classic seven-component decomposition result show the deficiencies of PCFCH and PEICH as reported in previous studies [12] when compared with the nine component results of Tables 3 and 4. We see that CFCH for Africa, for example, improved (0.996), but its Total Factor Productivity for Carbon Emissions did not. That is, CEPCH = MI C, the Malmquist Index for Carbon is 1.044, yet PCFCH indicates an improvement (0.954) in the seven-component decomposition. Although Africa is on the frontier of Technical Efficiency change, CEEFCH = 1, its frontier has not shifted with respect to Carbon Abatement Technology, CATECH > 1. Hence, by using CFCH, CEEFCH and CATECH we can show transparently and in a meaningful way that the Carbon Reduction Momentum for Africa in 2007-2008 is lagging behind by 3.86% for the reasons given.

However, Africa’s Energy Usage and Energy Savings were on the Energy Frontier (EUECH, ESTECH =1) and its Energy Intensity improved (0.979). Its Energy Conservation Momentum, therefore, was 2.12%. In this case, PEICH was incidentally meaningful, but it is not correct for the Middle East where both Energy Intensity and Factor Productivity declined. Hence, we conclude that PCFCH and PEICH are ambiguous factors that should be removed from Carbon Emission Reduction analysis.

Also, as mentioned earlier, the degrees of freedom used in our model have been corrected from the previous study by including 10 rather than 8 regions. We incorporate more information as well since each variable is ‘per capita.’ This approach takes annual changes in population into consideration across the frontier while not changing the production characteristics of each region.

One final issue regarding our choice of the VRS model: In Zhou & Ang’s study, the programming effects of CRS become obvious in the CATECH and ESTECH frontier shifts. These values are the same for all regions except the frontier DMU. We have determined that this effect is the result of CRS reduction, which seeks to put all DMUs on the constant return linear frontier of the efficient DMU. A comparison of the two models is given in Table 5 and it can be observed that the CRS model distorts the other components due to its uni-valued factors.

Table 2 Classic 7 Component Decomposition

<table>
<thead>
<tr>
<th>Region</th>
<th>CO2 CH</th>
<th>PCFCH</th>
<th>PEICH</th>
<th>GDPCH</th>
<th>CEEFCH</th>
<th>CATECH</th>
<th>EUEFCH</th>
<th>ESTECH</th>
</tr>
</thead>
<tbody>
<tr>
<td>OECD North America</td>
<td>0.966</td>
<td>1.011</td>
<td>0.988</td>
<td>0.996</td>
<td>1.000</td>
<td>0.983</td>
<td>1.000</td>
<td>0.987</td>
</tr>
<tr>
<td>OECD Pacific</td>
<td>0.993</td>
<td>1.013</td>
<td>0.994</td>
<td>1.000</td>
<td>1.000</td>
<td>0.993</td>
<td>1.000</td>
<td>0.994</td>
</tr>
<tr>
<td>OECD Europe</td>
<td>0.980</td>
<td>1.014</td>
<td>0.994</td>
<td>1.002</td>
<td>1.000</td>
<td>0.975</td>
<td>1.000</td>
<td>0.994</td>
</tr>
<tr>
<td>Africa</td>
<td>1.004</td>
<td>0.954</td>
<td>0.979</td>
<td>1.029</td>
<td>1.000</td>
<td>1.044</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Middle East</td>
<td>1.041</td>
<td>0.988</td>
<td>0.997</td>
<td>1.033</td>
<td>0.869</td>
<td>1.166</td>
<td>1.024</td>
<td>0.987</td>
</tr>
<tr>
<td>Non-OECD Europe</td>
<td>0.980</td>
<td>1.060</td>
<td>0.995</td>
<td>1.065</td>
<td>0.827</td>
<td>1.110</td>
<td>0.963</td>
<td>0.987</td>
</tr>
<tr>
<td>Former Soviet Union</td>
<td>1.025</td>
<td>1.034</td>
<td>0.995</td>
<td>1.051</td>
<td>0.848</td>
<td>1.148</td>
<td>0.987</td>
<td>0.987</td>
</tr>
<tr>
<td>Latin America</td>
<td>1.030</td>
<td>1.011</td>
<td>0.989</td>
<td>1.039</td>
<td>1.000</td>
<td>0.992</td>
<td>1.000</td>
<td>0.999</td>
</tr>
<tr>
<td>Asia</td>
<td>1.027</td>
<td>1.008</td>
<td>0.976</td>
<td>1.041</td>
<td>1.000</td>
<td>1.002</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>China</td>
<td>1.078</td>
<td>0.998</td>
<td>0.992</td>
<td>1.082</td>
<td>0.868</td>
<td>1.161</td>
<td>1.012</td>
<td>0.987</td>
</tr>
</tbody>
</table>

Table 3 New 9 Component Energy-Side Decomposition with Momentum

<table>
<thead>
<tr>
<th>Region</th>
<th>PCFCH</th>
<th>CF CH</th>
<th>1/MI C</th>
<th>CEPCH</th>
<th>CEEFCH</th>
<th>CATECH</th>
<th>Product</th>
<th>MV Carbon</th>
</tr>
</thead>
<tbody>
<tr>
<td>OECD North America</td>
<td>1.011</td>
<td>0.994</td>
<td>1.018</td>
<td>0.983</td>
<td>1.000</td>
<td>0.983</td>
<td>0.976</td>
<td>2.41%</td>
</tr>
<tr>
<td>OECD Pacific</td>
<td>1.013</td>
<td>1.005</td>
<td>1.007</td>
<td>0.993</td>
<td>1.000</td>
<td>0.993</td>
<td>0.998</td>
<td>0.20%</td>
</tr>
<tr>
<td>OECD Europe</td>
<td>1.014</td>
<td>0.989</td>
<td>1.026</td>
<td>0.975</td>
<td>1.000</td>
<td>0.975</td>
<td>0.963</td>
<td>3.81%</td>
</tr>
<tr>
<td>Africa</td>
<td>0.954</td>
<td>0.996</td>
<td>0.958</td>
<td>1.044</td>
<td>1.000</td>
<td>1.044</td>
<td>1.040</td>
<td>-3.86%</td>
</tr>
<tr>
<td>Middle East</td>
<td>0.988</td>
<td>1.001</td>
<td>0.987</td>
<td>1.013</td>
<td>0.869</td>
<td>1.166</td>
<td>1.014</td>
<td>-1.39%</td>
</tr>
<tr>
<td>Non-OECD Europe</td>
<td>1.060</td>
<td>0.973</td>
<td>1.089</td>
<td>0.918</td>
<td>0.827</td>
<td>1.110</td>
<td>0.894</td>
<td>11.86%</td>
</tr>
<tr>
<td>Former Soviet Union</td>
<td>1.034</td>
<td>1.007</td>
<td>1.027</td>
<td>0.974</td>
<td>0.848</td>
<td>1.148</td>
<td>0.981</td>
<td>1.98%</td>
</tr>
<tr>
<td>Latin America</td>
<td>1.011</td>
<td>1.003</td>
<td>1.008</td>
<td>0.992</td>
<td>1.000</td>
<td>0.992</td>
<td>0.996</td>
<td>0.42%</td>
</tr>
<tr>
<td>Asia</td>
<td>1.008</td>
<td>1.010</td>
<td>0.998</td>
<td>1.002</td>
<td>1.000</td>
<td>1.002</td>
<td>1.012</td>
<td>-1.22%</td>
</tr>
<tr>
<td>China</td>
<td>0.998</td>
<td>1.006</td>
<td>0.992</td>
<td>1.008</td>
<td>0.868</td>
<td>1.161</td>
<td>1.014</td>
<td>-1.38%</td>
</tr>
</tbody>
</table>
Ten Region Study Results

Two example results are given below: one by decade in Table 6, the other by region in Table 7. The remaining 13 combinations of regions and decades are found after the Conclusion in Tables 9-11.

Table 6 shows the decade following the demise of the Soviet Union. Its GDP declined sharply as did its CO2 emissions output due to interruptions in production presumably, and likely recording difficulties as well. A lack of efficiency and technology shift caused the Soviet Union to lose momentum in both Carbon Reduction (-38.8%) and Energy Reduction (-58.1%). The Non-OECD European countries followed a similar CO2 emissions reduction pattern, but due to a significant increase in factor productivity, both TFP C and TFP E increased. Hence, Carbon Emissions and Energy Usage Efficiency increased although their frontier lagged behind in terms of technological shift.

Last, as expected the correlation between the efficiency scores of the targeted Latent Variable and its reduction objective is very high, typically within ranges over 90%. In the Table 8 below KK is the first year in the range and LL is the last, that is, LL becomes KK in the next period. KL and LK use alternate reference technologies. The Latent Variable is Carbon Emissions and the objective of the minimization LP is Energy Consumption. Notice that correlation between the reduction variables is somewhat strong advances once again, especially in Carbon Emissions and Energy Usage Efficiency and in Energy Intensity reduction. Similar interpretations can be made on the full set of charts in the appendix. Also note that when CEEFCH and EUEFCH equal one the DMU is on the frontier.

Table 7 shows the Soviet Union as it progressed through the decades. It had excellent momentum in both reduction areas in the 1970’s; this momentum was lost during the transition periods. In the last decade they have made strong advances once again, especially in Carbon Emissions and Energy Usage Efficiency and in Energy Intensity reduction. Similar interpretations can be made on the full set of charts in the appendix. Also note that when CEEFCH and EUEFCH equal one the DMU is on the frontier.

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convex hull as is the case for VRS models.

Also note that by using alternate reference periods production sets from year to year may be different; we can see this difference in the correlation values – hence, the decade differences are much greater than for the single year period as we would expect.

**Table 6 Carbon and Energy Momentum Compared for Decade '89 to '98**

<table>
<thead>
<tr>
<th>VRS-LV 1989-1998</th>
<th>Carbon Reduction Momentum</th>
<th>Energy Reduction Momentum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CO2CH</td>
<td>TFP C</td>
</tr>
<tr>
<td>OECD North America</td>
<td>-4.3%</td>
<td>24.2%</td>
</tr>
<tr>
<td>OECD Pacific</td>
<td>17.5%</td>
<td>32.0%</td>
</tr>
<tr>
<td>OECD Europe</td>
<td>-5.4%</td>
<td>38.2%</td>
</tr>
<tr>
<td>Africa</td>
<td>-5.8%</td>
<td>1.6%</td>
</tr>
<tr>
<td>Middle East</td>
<td>20.7%</td>
<td>-5.6%</td>
</tr>
<tr>
<td>Non-OECD Europe</td>
<td>-36.5%</td>
<td>53.4%</td>
</tr>
<tr>
<td>Former Soviet Union</td>
<td>-39.2%</td>
<td>-38.8%</td>
</tr>
<tr>
<td>Latin America</td>
<td>18.0%</td>
<td>-3.6%</td>
</tr>
<tr>
<td>Asia</td>
<td>36.2%</td>
<td>-19.3%</td>
</tr>
<tr>
<td>China</td>
<td>25.7%</td>
<td>8.3%</td>
</tr>
</tbody>
</table>

**Table 7 Carbon and Energy Momentum for the Former Soviet Union over Four Decades and '07 - '08**

<table>
<thead>
<tr>
<th>Former Soviet Union</th>
<th>Carbon Reduction Momentum</th>
<th>Energy Reduction Momentum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CO2CH</td>
<td>TFP C</td>
</tr>
<tr>
<td>2007-2008</td>
<td>2.5%</td>
<td>2.7%</td>
</tr>
<tr>
<td>1998-2007</td>
<td>11.5%</td>
<td>53.8%</td>
</tr>
<tr>
<td>1989-1998</td>
<td>-39.2%</td>
<td>-38.8%</td>
</tr>
<tr>
<td>1980-1989</td>
<td>5.1%</td>
<td>12.3%</td>
</tr>
<tr>
<td>1971-1980</td>
<td>26.0%</td>
<td>68.5%</td>
</tr>
</tbody>
</table>

**CONCLUSION**

This paper has applied a new methodology developed for DEA analysis that requires the simultaneous reduction of input and output variables. The Latent Variable is the result of an equality specification on the objective reduction variable. The input minimization constraint then sympathetically reduces output variables subject to a ‘less than’ inequality. Hence, outputs can be separated as desirable and undesirable while inputs can also be separated according to production parameters. This approach complies with the production process assumptions that have been tacitly ignored in other studies. Hence, Latent Variable methodologies can be easily targeted to any situation while preserving the production set. As expected the correlation between the efficiency scores of the targeted Latent Variable and its reduction objective is very high, typically within ranges of over 90%.

In summary, the Latent Variable model advances DEA environmental technologies by making reduction of undesirable output variables possible without violating the production set assumptions. The relatively high and consistent correlations shows in Table 8 are evidence of this advantage. But one criticism is that an oriented radial model such as this does not account for all the slack in the variables. We will address this in our next paper by showing that the Latent Variable model gives efficiency scores surprisingly close to the Reverse SBM model we developed in a previous paper [19].

**Table 8 Reduction Variable Correlation between Malmquist Decomposition Elements**

<table>
<thead>
<tr>
<th>Correlation Between Latent Variable &amp; Objective</th>
<th>KK</th>
<th>LL</th>
<th>KL</th>
<th>JK</th>
</tr>
</thead>
<tbody>
<tr>
<td>71-80 (crs)</td>
<td>0.806</td>
<td>0.834</td>
<td>0.834</td>
<td>0.771</td>
</tr>
<tr>
<td>1971-80</td>
<td>0.948</td>
<td>0.967</td>
<td>0.840</td>
<td>0.844</td>
</tr>
<tr>
<td>1980-89</td>
<td>0.967</td>
<td>0.975</td>
<td>0.971</td>
<td>0.868</td>
</tr>
<tr>
<td>1989-98</td>
<td>0.975</td>
<td>0.981</td>
<td>0.877</td>
<td>0.932</td>
</tr>
<tr>
<td>1998-07</td>
<td>0.981</td>
<td>0.961</td>
<td>0.899</td>
<td>0.977</td>
</tr>
<tr>
<td>2007-08</td>
<td>0.961</td>
<td>0.975</td>
<td>0.958</td>
<td>0.967</td>
</tr>
<tr>
<td>GeoMean</td>
<td>0.938</td>
<td>0.947</td>
<td>0.895</td>
<td>0.890</td>
</tr>
</tbody>
</table>

As well this paper has applied a new nine-component decomposition model that rectifies an error in the seven-component model: we have shown that Potential Carbon Factor and Potential Energy Intensity have no meaning since their direction of movement is ambiguous. These components have been replaced by their actual (rather than Potential) components and the inverse of their Malmquist...
Indices. With this transparency, Reduction Momentum can be calculated for both Carbon Emissions and Energy Conservation. These allow a meaningful assessment of the actual progress or regress of the regions in question. As a result our values can be seen to parallel the historical process of the regions analyzed, such as the FSU and China.

### Table 9 Four DecadeMomentums by Region: OECD

#### OECD North America

<table>
<thead>
<tr>
<th>Period</th>
<th>Carbon Reduction Momentum</th>
<th>Energy Reduction Momentum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CO2CH</td>
<td>TFP C</td>
</tr>
<tr>
<td>2007-2008</td>
<td>-3.4%</td>
<td>1.8%</td>
</tr>
<tr>
<td>1998-2007</td>
<td>0.0%</td>
<td>24.1%</td>
</tr>
<tr>
<td>1989-1998</td>
<td>-4.1%</td>
<td>24.2%</td>
</tr>
<tr>
<td>1980-1989</td>
<td>-5.4%</td>
<td>39.5%</td>
</tr>
<tr>
<td>1971-1980</td>
<td>1.4%</td>
<td>23.4%</td>
</tr>
</tbody>
</table>

#### OECD Pacific

<table>
<thead>
<tr>
<th>Period</th>
<th>Carbon Reduction Momentum</th>
<th>Energy Reduction Momentum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CO2CH</td>
<td>TFP C</td>
</tr>
<tr>
<td>2007-2008</td>
<td>-0.7%</td>
<td>0.7%</td>
</tr>
<tr>
<td>1998-2007</td>
<td>12.8%</td>
<td>15.3%</td>
</tr>
<tr>
<td>1989-1998</td>
<td>17.5%</td>
<td>32.0%</td>
</tr>
<tr>
<td>1980-1989</td>
<td>10.0%</td>
<td>13.4%</td>
</tr>
<tr>
<td>1971-1980</td>
<td>14.8%</td>
<td>45.9%</td>
</tr>
</tbody>
</table>

#### OECD Europe

<table>
<thead>
<tr>
<th>Period</th>
<th>Carbon Reduction Momentum</th>
<th>Energy Reduction Momentum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CO2CH</td>
<td>TFP C</td>
</tr>
<tr>
<td>2007-2008</td>
<td>-2.0%</td>
<td>2.6%</td>
</tr>
<tr>
<td>1998-2007</td>
<td>-2.1%</td>
<td>11.2%</td>
</tr>
<tr>
<td>1989-1998</td>
<td>-5.4%</td>
<td>38.2%</td>
</tr>
<tr>
<td>1980-1989</td>
<td>-8.0%</td>
<td>18.2%</td>
</tr>
<tr>
<td>1971-1980</td>
<td>7.2%</td>
<td>15.8%</td>
</tr>
</tbody>
</table>
### Table 10 Four Decade Momentums for Other Regions

<table>
<thead>
<tr>
<th>Region</th>
<th>Carbon Reduction Momentum</th>
<th>Energy Reduction Momentum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007-2008</td>
<td>0.4% -4.2%</td>
<td>2.9% 0.0%</td>
</tr>
<tr>
<td>1998-2007</td>
<td>9.6% -4.0%</td>
<td>19.5% -9.3%</td>
</tr>
<tr>
<td>1989-1998</td>
<td>-5.8% 1.6%</td>
<td>-4.3% 3.7%</td>
</tr>
<tr>
<td>1980-1989</td>
<td>14.8% -15.7%</td>
<td>-4.3% 9.6%</td>
</tr>
<tr>
<td>1971-1980</td>
<td>28.7% -16.7%</td>
<td>8.2% -20.5%</td>
</tr>
<tr>
<td>Middle East</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007-2008</td>
<td>4.3% -1.3%</td>
<td>3.3% -1.0%</td>
</tr>
<tr>
<td>1998-2007</td>
<td>28.0% -6.1%</td>
<td>21.8% -7.5%</td>
</tr>
<tr>
<td>1989-1998</td>
<td>20.7% -5.6%</td>
<td>14.1% -9.6%</td>
</tr>
<tr>
<td>1980-1989</td>
<td>24.3% -57.9%</td>
<td>-32.3% -48.2%</td>
</tr>
<tr>
<td>1971-1980</td>
<td>96.3% 18.1%</td>
<td>28.0% -0.9%</td>
</tr>
<tr>
<td>Non-OECD Europe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007-2008</td>
<td>-2.0% 8.5%</td>
<td>6.5% 5.2%</td>
</tr>
<tr>
<td>1998-2007</td>
<td>11.6% 42.4%</td>
<td>57.0% 37.1%</td>
</tr>
<tr>
<td>1989-1998</td>
<td>-36.5% 53.4%</td>
<td>-2.2% 37.1%</td>
</tr>
<tr>
<td>1980-1989</td>
<td>10.8% -1.1%</td>
<td>9.2% 0.5%</td>
</tr>
<tr>
<td>1971-1980</td>
<td>41.1% 18.7%</td>
<td>75.5% 3.7%</td>
</tr>
<tr>
<td>Former Soviet Union</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007-2008</td>
<td>2.5% 2.7%</td>
<td>5.1% 2.7%</td>
</tr>
<tr>
<td>1998-2007</td>
<td>11.5% 53.8%</td>
<td>91.7% 52.4%</td>
</tr>
<tr>
<td>1989-1998</td>
<td>-39.2% -38.8%</td>
<td>-58.8% -33.4%</td>
</tr>
<tr>
<td>1980-1989</td>
<td>5.1% 12.3%</td>
<td>13.8% 2.6%</td>
</tr>
<tr>
<td>1971-1980</td>
<td>26.0% 68.5%</td>
<td>40.5% 37.5%</td>
</tr>
<tr>
<td>Latin America</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007-2008</td>
<td>3.0% 0.8%</td>
<td>3.9% 0.1%</td>
</tr>
<tr>
<td>1998-2007</td>
<td>5.4% 12.9%</td>
<td>18.9% 3.0%</td>
</tr>
<tr>
<td>1989-1998</td>
<td>18.0% -3.6%</td>
<td>12.0% -0.1%</td>
</tr>
<tr>
<td>1980-1989</td>
<td>-8.9% 3.3%</td>
<td>-4.7% -1.1%</td>
</tr>
<tr>
<td>1971-1980</td>
<td>26.9% 1.7%</td>
<td>31.3% 3.4%</td>
</tr>
<tr>
<td>Asia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007-2008</td>
<td>2.7% -0.2%</td>
<td>4.1% 0.0%</td>
</tr>
<tr>
<td>1998-2007</td>
<td>30.9% -0.3%</td>
<td>48.2% 0.0%</td>
</tr>
<tr>
<td>1989-1998</td>
<td>36.2% -19.3%</td>
<td>32.8% -1.1%</td>
</tr>
<tr>
<td>1980-1989</td>
<td>36.1% -17.9%</td>
<td>33.4% -0.8%</td>
</tr>
<tr>
<td>1971-1980</td>
<td>36.5% -20.4%</td>
<td>22.2% -4.7%</td>
</tr>
<tr>
<td>China</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007-2008</td>
<td>7.8% -0.8%</td>
<td>8.2% 0.2%</td>
</tr>
<tr>
<td>1998-2007</td>
<td>86.0% -7.3%</td>
<td>116.3% 8.6%</td>
</tr>
<tr>
<td>1989-1998</td>
<td>25.7% 8.3%</td>
<td>110.5% 13.1%</td>
</tr>
<tr>
<td>1980-1989</td>
<td>28.9% -18.4%</td>
<td>102.1% -12.9%</td>
</tr>
<tr>
<td>1971-1980</td>
<td>46.9% -31.9%</td>
<td>49.4% -23.6%</td>
</tr>
</tbody>
</table>

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Table 11 Nine-Component Decompositions by Decade for World Regions
VRS-LV
1971-1980
OECD North America
OECD Pacific
OECD Europe
Africa
Middle East
Non-OECD Europe
Former Soviet Union
Latin America
Asia
China

VRS-LV
1980-1989
OECD North America
OECD Pacific
OECD Europe
Africa
Middle East
Non-OECD Europe
Former Soviet Union
Latin America
Asia
China

VRS-LV
1989-1998
OECD North America
OECD Pacific
OECD Europe
Africa
Middle East
Non-OECD Europe
Former Soviet Union
Latin America
Asia
China

VRS-LV
1998-2007
OECD North America
OECD Pacific
OECD Europe
Africa
Middle East
Non-OECD Europe
Former Soviet Union
Latin America
Asia
China

VRS-LV
2007-2008
OECD North America
OECD Pacific
OECD Europe
Africa
Middle East
Non-OECD Europe
Former Soviet Union
Latin America
Asia
China

CO2CH
1.4%
14.8%
7.2%
28.7%
96.3%
41.1%
26.0%
26.9%
36.5%
46.9%

Carbon Reduction Momentum
TFP C
CFCH
CEEFCH CATECH
23.4%
0.976
1.000
0.811
45.9%
0.954
1.000
0.685
15.8%
0.942
1.051
0.822
-16.7%
1.156
1.074
1.118
18.1%
1.036
1.000
0.847
18.7%
0.986
0.790
1.066
68.5%
0.948
0.603
0.984
1.7%
1.070
0.933
1.054
-20.4%
1.159
1.000
1.256
-31.9%
1.122
1.077
1.365

MV C
26.4%
53.0%
22.8%
-27.9%
14.0%
20.4%
77.8%
-4.9%
-31.3%
-39.4%

GDPCH
20.6%
30.6%
25.0%
8.2%
28.0%
75.5%
40.5%
31.3%
22.2%
49.4%

Energy Reduction Momentum
TFP E
EICH
EUEFCH ESTECH
21.7%
0.861
1.000
0.822
7.3%
0.922
1.000
0.932
10.8%
0.910
1.003
0.900
-20.5%
1.030
1.257
1.000
-0.9%
1.481
1.000
1.009
3.7%
0.815
0.729
1.322
37.5%
0.947
0.651
1.117
3.4%
0.903
0.705
1.371
-4.7%
0.964
1.000
1.049
-23.6%
0.876
1.111
1.178

MV E
41.4%
16.4%
21.7%
-22.8%
-33.1%
27.2%
45.3%
14.5%
-1.1%
-12.9%

CO2CH
-5.4%
10.0%
-8.0%
14.8%
24.3%
10.8%
5.1%
-8.9%
36.1%
28.9%

Carbon Reduction Momentum
TFP C
CFCH
CEEFCH CATECH
39.5%
0.967
1.000
0.717
13.4%
0.933
1.000
0.882
18.2%
0.887
1.064
0.795
-15.7%
1.068
1.107
1.071
-57.9%
0.966
2.778
0.856
-1.1%
1.031
1.046
0.966
12.3%
0.929
1.156
0.770
3.3%
0.928
1.000
0.968
-17.9%
1.135
1.000
1.219
-18.4%
1.081
0.948
1.292

MV C
44.3%
21.6%
33.2%
-21.0%
-56.5%
-4.1%
20.9%
11.4%
-27.7%
-24.5%

GDPCH
19.0%
34.6%
18.7%
-4.3%
-32.3%
9.2%
13.8%
-4.7%
33.4%
102.1%

Energy Reduction Momentum
TFP E
EICH
EUEFCH ESTECH
35.5%
0.822
1.000
0.738
3.8%
0.876
1.000
0.963
3.4%
0.873
1.120
0.864
-9.6%
1.124
1.087
1.017
-48.2%
1.903
1.923
1.005
0.5%
0.983
0.970
1.026
2.6%
0.994
1.041
0.936
-1.1%
1.030
1.000
1.011
-0.8%
0.899
1.000
1.008
-12.9%
0.590
0.995
1.154

MV E
64.7%
18.5%
18.4%
-19.6%
-72.8%
2.2%
3.2%
-4.0%
10.4%
47.5%

CO2CH
-4.1%
17.5%
-5.4%
-5.8%
20.7%
-36.5%
-39.2%
18.0%
36.2%
25.7%

Carbon Reduction Momentum
TFP C
CFCH
CEEFCH CATECH
24.2%
0.980
1.000
0.805
32.0%
0.932
1.000
0.757
38.2%
0.923
0.894
0.809
1.6%
0.961
0.841
1.170
-5.6%
0.972
1.006
1.053
53.4%
0.889
0.618
1.055
-38.8%
0.929
1.621
1.007
-3.6%
1.055
1.000
1.038
-19.3%
1.109
1.000
1.240
8.3%
1.043
0.752
1.228

MV C
26.7%
41.7%
49.8%
5.7%
-2.9%
72.6%
-34.1%
-8.7%
-27.3%
3.9%

GDPCH
14.8%
17.6%
16.0%
-4.3%
14.1%
-2.2%
-58.8%
12.0%
32.8%
110.5%

Energy Reduction Momentum
TFP E
EICH
EUEFCH ESTECH
20.0%
0.852
1.000
0.833
0.5%
1.072
1.000
0.995
12.8%
0.884
0.890
0.995
3.7%
1.024
0.731
1.319
-9.6%
1.088
1.094
1.011
37.1%
0.730
0.721
1.012
-33.4%
1.589
1.494
1.005
-0.1%
0.998
1.000
1.001
-1.1%
0.925
1.000
1.011
13.1%
0.573
0.790
1.119

MV E
40.8%
-6.3%
27.6%
1.2%
-16.8%
87.7%
-58.1%
0.1%
6.9%
97.4%

CO2CH
0.0%
12.8%
-2.1%
9.6%
28.0%
11.6%
11.5%
5.4%
30.9%
86.0%

Carbon Reduction Momentum
TFP C
CFCH
CEEFCH CATECH
24.1%
0.996
1.000
0.806
15.3%
1.033
1.000
0.867
11.2%
0.969
1.000
0.900
-4.0%
1.007
1.000
1.042
-6.1%
0.986
1.188
0.896
42.4%
1.002
0.793
0.886
53.8%
0.961
0.715
0.909
12.9%
0.958
1.000
0.886
-0.3%
1.078
1.000
1.003
-7.3%
1.096
1.117
0.966

MV C
24.5%
11.6%
14.7%
-4.7%
-4.7%
42.2%
60.0%
17.8%
-7.5%
-15.5%

GDPCH
18.1%
20.8%
19.6%
19.5%
21.8%
57.0%
91.7%
18.9%
48.2%
116.3%

Energy Reduction Momentum
TFP E
EICH EUEFCH
ESTECH
22.8%
0.849
1.000
0.814
13.0%
0.905
1.000
0.885
6.8%
0.844
1.000
0.936
-9.3%
0.911
1.000
1.102
-7.5%
1.067
1.159
0.933
37.1%
0.710
0.793
0.920
52.4%
0.605
0.713
0.920
3.0%
0.925
1.000
0.971
0.0%
0.819
1.000
1.000
8.6%
0.784
0.966
0.953

MV E
44.6%
24.9%
26.5%
-0.4%
-13.3%
93.2%
151.8%
11.3%
22.0%
38.5%

CO2CH
-3.4%
-0.7%
-2.0%
0.4%
4.1%
-2.0%
2.5%
3.0%
2.7%
7.8%

Carbon Reduction Momentum
TFP C
CFCH
CEEFCH CATECH
1.8%
0.994
1.000
0.983
0.7%
1.005
1.000
0.993
2.6%
0.989
1.000
0.975
-4.2%
0.996
1.000
1.044
-1.3%
1.001
0.869
1.166
8.9%
0.973
0.827
1.110
2.7%
1.007
0.848
1.148
0.8%
1.003
1.000
0.992
-0.2%
1.010
1.000
1.002
-0.8%
1.006
0.868
1.161

MV C
2.4%
0.2%
3.8%
-3.9%
-1.4%
11.9%
2.0%
0.4%
-1.2%
-1.4%

GDPCH
-0.4%
0.0%
0.2%
2.9%
3.3%
6.5%
5.1%
3.9%
4.1%
8.2%

Energy Reduction Momentum
TFP E
EICH
EUEFCH ESTECH
1.3%
0.976
1.000
0.987
0.6%
0.988
1.000
0.994
0.6%
0.989
1.000
0.994
0.0%
0.979
1.000
1.000
-1.0%
1.007
1.024
0.987
5.2%
0.946
0.963
0.987
2.7%
0.970
0.987
0.987
0.1%
0.988
1.000
0.999
0.0%
0.976
1.000
1.000
0.2%
0.990
1.012
0.987

MV E
3.8%
1.9%
1.7%
2.1%
-1.7%
11.2%
5.9%
1.3%
2.4%
1.1%

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References


MOBILE INTERNET SERVICES CONTINUANCE: A RATIONAL DECISION MAKING AND AUTOMATIC BEHAVIORAL PERSPECTIVE

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ABSTRACT

No researchers in the IS literature tried to provide and explain an integrated human behavioral processes framework. This paper attempts to fill this gap by proposing a rational decision making and automatic behavior framework and suggesting rational behaviors to consist of cognitive, affective and judgmental components while automatic behaviors to consist of affective and habitual components. This study also provides implications to practitioners who have been finding it difficult to maintain or increase the continuing usage of mobile Internet services. The findings validate our integrated rational decision making and automatic behavior framework and suggest practitioners to increase the perceived value of the mobile Internet services.

Keywords: Behavior, habit, perceived value, IS continuance, mobile Internet service

INSTRUCTIONS

Human behaviors have been mostly examined in terms of usage and adoption behavior in the IS literature. Most recently, post-adoption behaviors have been attracting interest. To explain IS continuance or post-adoption behavior, [20] developed a continuance model based on the confirmation-disconfirmation paradigm while [61] integrated adoption and post-adoption model was based on both TPB and a subset of Triandis model [90]. However, TPB and TRA are incomplete and focused too much on cognition and paid little attention to affective behavioral components [46] [17] [47]. Going by this argument, Bhattacharjee’s model [20] is incomplete too for failing to consider habits. Belk [16] and Holbrook [47] suggested that behavioral models need to integrate all behavioral mechanisms in order to be complete and to be able to predict behaviors in various situations. Therefore, there is the need to identify and explain the various human behavioral processes and explore the possibility of integrating them in one model that will be more comprehensive in explaining human behaviors under various conditions.

In order to develop and explain a comprehensive model, an extensive literature review of human behaviors was conducted. Human behavioral studies have been conducted across various domains such as in marketing e.g. [6] [88], economics e.g. [49] [54], psychology e.g. [40], and information systems e.g. [29]. These studies have evolved in many directions including behavioral models that focused solely on cognition or solely on affect, or integrated both cognition and affect with either the perspective of the behavior being controlled by cognition or by affect, and automatic behaviors [16] [47]. Ouellette and Wood [68] considered human behaviors to consist of a dual-mode processing: the first one being conscious decision making and the second one automatic behavior. In their model, they explored the dual processes only via intention, past behaviors and future behavior variables. In our quest to develop a comprehensive model, we recognized this dual classification to be our starting point. They are complementary and broad enough to allow the development of a comprehensive model. Conscious decision making or actions refer to behaviors that involve reasoned actions requiring conscious cognitive processing [93]. We, therefore, termed it as rational decision making. Automatic behavior or reactions refer to unconscious behaviors that involve little or no cognitive processing and proceeds rather automatically. For this reason, we kept the terminology automatic behaviors to describe this type of human behavior. In the next step of our research, we explored the breakdowns of these two classifications. We conclude, from an in-depth literature review, rational decision making to be composed of cognition, affect [16] [47] and judgment [2] [5]. Automatic behaviors, on the other hand, consist of habit [68] and affect [24]. The dual nature of affect is due to the fact that it can either be cognitively evaluated [13] [77] [78] or it can unconsciously evoke behavior [47].

While adoption studies in the IS field abound, researchers in IS only recently started to show interest in IS continuance [61]. They realized IS adoption is only the first step towards overall IS success [20] and that IS continuance is important to ensure the overall success of an information system [20] [61]. One area where IS continuance research is required is that of mobile Internet services. Initial promotions have led people to start using mobile Internet services, but majority of them subsequently stopped its usage after the promotion [81]. Understanding IS continuance of mobile Internet services is a must if these services are to take off and achieve their huge potential economic success [21] [26].

Given the weaknesses and lack of comprehensive understanding of human behaviors in the IS literature, as highlighted in the opening paragraph, this study aims to examine and shed light on the processes through which human behavior operates. The paper integrates and tests rational decision making and automatic factors in a behavioral model. Because of its importance, IS continuance in the context of mobile Internet services is being studied. This study addresses the questions: What are the prominent factors that influence the continuance behavior of individual consumers? Through what processes these factors affect consumers’ behavior?

This study presents important theoretical and practical contributions. Theoretically, this study addresses the various concerns targeted at previous behavioral researches in the IS research domain by identifying and explaining the processes of human behavior. We integrated these processes to provide a more complete and comprehensive model. Variables for IS continuance in the individual context (mobile Internet services) were also identified. Practically, implications are drawn for managers to generate more revenues from existing customers. By having a better understanding of consumer...
behaviors, we are able to suggest how to increase consumers’ continuance intention. For example, managers should provide and encourage free trials of their products or services over a sufficiently long time period in order for customers to develop a habit of using these products/services.

CONCEPTUAL BACKGROUND

Mobile Internet Services

Mobile Internet services essentially provide the same services as stationary Internet. The services offered by the mobile Internet can be categorized into 3Cs — Commerce, Communication and Contents. Commerce ranges from mobile banking and e-ticketing to physical product purchases while email and interactive services such as Google Chat are considered as communication services. Contents include downloads, news, traffic/stock updates and other time-sensitive, location-based services [52]. The services are offered on mobile devices such as mobile phone, PDA or smart phone. Mobile Internet services create an opportunity to deliver new services to existing customers and attract new ones. The major characteristics differentiating mobile Internet services from stationary Internet are mobility and reach. Users can consume mobile Internet services wherever they happen to be (mobility) and can be reached at any time (reach). Researchers need to provide practitioners advice on how best to achieve this. Only a few studies [8] have explored how individuals use mobile Internet services. In order for mobile Internet services to exploit its huge economic potential, research on consumer continuance behavior in the mobile Internet services context is sorely needed.

Human Behaviors

In our literature review, we uncovered various components of human behaviors. They are mainly cognitive, affective and automatic behaviors. Human behaviors have been classified in two categories: one involving conscious deliberation and the other one involving automatic reliance on well-established routines [39] [70] [25] [68] [83] with some researchers calling it a dual-mode processing model [16] [47] [68] [83] [58]. According to Ouellette and Wood [68], past behavior predicts future behavior via two processes: It can either be guided by conscious deliberation or by automatic reliance on well-established routines. In the first process, when behaviors are not well learned or when they are performed in unstable or difficult contexts, conscious decision making is likely to be necessary to initiate and carry out the behavior. In the second process well-practiced behaviors in constant contexts recur because the processing that initiates and controls their performance becomes automatic. Ouellette and Wood [68] considered conscious deliberation as conscious decision making and automatic actions as automatic behaviors. We refer to conscious deliberation as rational decision making and automatic reliance on well established behaviors as automatic behavior. These two classifications are comprehensive and complementary and provided a good approach to develop an encompassing framework representing various components of human behaviors. We proceeded, in a top-down approach, from these two classifications to make sure that we do not miss out on any behavioral components. The criteria for the classifications and the components of the two categories are further elaborated in the sub-sections below.

Rational Decision Making

Research in IS literature has usually assumed a highly rational model, with theories such as TRA [40], TPB [11] and Technological Adoption Model (TAM) [29], in which users’ behavior are based on the basis of reasons, on the beliefs about the outcome of an action. This assumption is based on the premise that behavior is purposive, planned, and conscious[16], that is, the most proximal cause of behavior is the intention that represents the person’s motivation in the sense of his or her conscious plan to exert effort to carry out a behavior [37]. Rational decision making involves controlled reasoning processes [68]. Azjen and Fishbein [4] labeled their approach as Theory of reasoned action because they believe human beings are rational and are not controlled by unconscious motives. The goal-directedness of human behaviors are based on expectancy-value models of attitudes and decision making, themselves deeply rooted in theories of rational choice [93]. These studies emphasize the deliberate character of individual choice suggesting that choices are made consciously. Thus, rational decision making assumes the existence of beliefs. These beliefs or thoughts are cognitive in nature [67]. We refer to this component as cognition. Some reasoned action or rational decision making models have been criticized for focusing too much on cognition and ignoring affect [46] [47]. However, affect does form part of rational decision making [55] [43] [96]. From the expectancy-value perspective, humans evaluate the potential outcome of a behavior and form their judgment about the utility of this behavior [11] [14]. Since attitude involves evaluation, that is cognitive processing, it is part of the rational decision making process.

Automatic Behavior

In automatic behavior, behavioral responses are automatic in the sense that the cognitive processing that initiates and controls the response becomes automatic unlike in rational decision making [68].

Automatic behaviors posed difficulties to cognitive theories like TRA and TPB [74] [84]. Research studies have proven that traditional reasoned actions models failed to predict behavior involving automation [16] [68] [93]. This laid rise to the abovementioned criticism of traditional reasoned actions for failing to take automatic behavior into consideration. Therefore, to be complete, behavioral models need to consider both rational decision making and automatic behaviors. The components of automatic behaviors habit and affect. From the discussion of affect as rational decision making and the discussion of affect as automatic, we can understand why affect is involved in both rational decisions making as well as automatic processes.
THEORETICAL FRAMEWORK

In the literature review, we found that behavioral models that focused on cognition and ignored affect were criticized for being incomplete. Behavioral models that ignored habituation issues were criticized too because they were unable to predict repeated behaviors. Belk [16] and Holbrook [47] each suggested a framework that should be able to explain human behaviors in all different types of situations. In their conceptual framework, they tried to encompass as much different situations as possible. However, they never developed a model from their framework and never conducted empirical testing. From our analysis of past literatures, we categorized behavioral processing mechanisms as rational decision making and automatic behavioral processes which we integrated into one conceptual framework. In the framework, automatic behavior processes consists of the relationship between habit and behavior [68] [95] and the relationship between affect and behavioral intention [12] [58]. The habit-behavior mechanism initiates and controls well-practiced behaviors in constant contexts and proceeds automatically and unconsciously [68]. Affect-behavioral intention is automatic because people’s affect automatically influence behavioral intention along this path. People cannot choose their emotions whereas they can choose what to believe in; rather, emotions unconsciously influence their behavioral intention [32] [75]. Rational decision making processes, on the other hand, consist of judgment-behavioral intention [40] [1] [29], cognition-behavioral intention [94] [14], cognition-judgment [40] [29] [13] affect-judgment [77] [13] [76] and, ultimately, behavioral intention-behavior [40] [90] [29] relationships. Thus, this type of human behavior is volitional. The various relationships of the two processes, supported by background theories, are discussed in more details below.

Rational Decision Making Process

Relationship from Cognition to Behavioral Intention

The effect of cognition on behavioral intention was initially brought up by Triandis [89], who viewed cognition as having a direct effect on behavioral intention. According to the self-efficacy theory [14], behavior would be best predicted by considering two outcome decisions: outcome expectancy judgment and self-efficacy judgment. In outcome expectancy, behavioral intention is influenced by beliefs (cognitive factors) that certain behaviors will lead to certain outcomes. In self-efficacy judgment, behavioral intentions are affected by the beliefs of whether one can effectively perform the behaviors necessary to produce the outcome. These two outcome judgments are different because the belief that a certain outcome can be produced by a certain behavior does not imply that a person will think that he can perform that behavior [38]. In the case of mobile Internet services continuance, if a consumer believes that continuing using mobile Internet services will result in useful benefits (outcome judgments), and that he will have no difficulty in continuing the usage of mobile Internet services, then the person will exhibit a continuance behavioral intention towards that service.

Relationship from Judgment to Behavioral Intention

Humans evaluate situations rationally and form intentions [40]. In our theoretical framework, judgment is used as a surrogate for evaluative decision-making processes. Among those included under the umbrella of evaluative judgment are attitudes, overall utility and perceived value constructs. Bagozzi [13] considered attitude to consist of cognitive and evaluative judgments. In TRA, attitudes towards the behavior refer to people’s positive or negative evaluation of performing the behavior. In TRA literature, the relationship between attitude and behavioral intention is well documented and empirical supported. These theories emphasize the reason-based antecedents of behavior.

Relationship from Cognition to Judgment

Some of the antecedents of judgment can be categorized as a set of cognitive factors. The effect of beliefs on intention (judgment) was initially brought up by Triandis [89]. He viewed cognitive factors as having a direct effect on behavioral intentions. The direct belief-intention link was also supported by Bagozzi [11]. He suggested that this path can be considered as an expectancy-value judgment that works through stored imperatives in memory. A possible explanation is that these beliefs achieve a personal goal, which in turn, influences one’s behavioral intention to act. The relationship can be further supported by Mental Accounting [88]. According to the theory, total utility consists of transaction and acquisition utility. Total utility is the overall evaluative judgment in terms of the utility of the outcome of the transaction and acquisition. Evaluation of cognitive factors, such as perceived price, is involved in evaluating the acquisition utility. Therefore, cognitive factors are antecedents to judgment.

Relationship from Affect to Judgment

Affective factors form the other category of judgment antecedents. In fact, attitude has been recently defined as a summary evaluation of an object, more specifically, consisting of affective and cognitive judgments [13]. The affective dimension of attitude, prior to disentanglement, lays the foundation for affect as an antecedent of the more judgmental attitude. The “affect-as-information” model further reinforces the relationship between affect and judgment [77] [78]. In this model, people rely on their feelings to form judgments because they perceive feelings to contain valuable judgmental information. By holding the target’s representations in their minds, they will thus ask themselves, “How do I feel about it?” [77]. But first, the feelings or affect must be regarded as representative of the target. Only then will these subtle feelings be incorporated in the individual’s evaluations of the target. Therefore, affect predict acquisition utility (acquisition judgment) and, subsequently, total utility (overall judgment).
According to Triandis [91], behavioral intentions are instructions people give to themselves to behave in certain ways. It is widely accepted that intention is the mediator between behavior and other factors leading to behavior ([40] [90], [47]). This relationship has been empirically tested. Theories that support this relationship include well-known TRA [40], TPB [1] and Triandis model [90]. In these theories intention to act or not to act is regarded as the immediate determinant of the action itself. According to Belk [16], an individual’s behavioral intention may change before he actually carries out the behavior. Therefore, we include the intention-behavior relationship in our theoretical framework instead of using intention as a surrogate.

**Automatic Behavioral Process**

**Relationship from Affect to Behavioral Intention**

Human behavior has been described as a hybrid mechanism by Romer [73]: feeling-based and thought-based mechanisms. The feeling-based mechanism embodies the emotion-intention relationship. The consummatory and instrumental motives in the consumption context are based on intrinsic and extrinsic rewards respectively. While consumers with instrumental motive are concerned by the utility of the products/services, those with consummatory motives are more concerned about their affective experience. Thus, they will more likely rate the feeling experienced as very relevant [45]. The theory identifies coping responses as important mechanisms to infer action and goal attainment from feelings. Depending on the emotions generated, behavioral intention emerge to activate plans in order to avoid undesirable outcomes, realize goals, tolerate negative conditions and/or increase or maintain positive outcomes [12]. Some studies have included action tendencies, together with reactions to appraisals of events, in the definition of affect [43]. Yet others even stated that these action tendencies or behavioral intentions are automatic, “pre-wired” responses linked to emotions [56] [13], implying emotions are natural antecedents of behavioral intentions.

**Relationship from Habit to Behavior**

Behaviors follow the habit-driven route when the behavior is repeatedly and satisfactorily executed and becomes habitual, thus losing its reasoned character. Behavior has thus been performed many times in the past are encoded in memory such that environmental cues serve to automatically elicit the behavior. Behavior may then be more guided by the automaticity of stimulus-response relations, and less by attitudes and intentions [93]. One's intentions to perform a new behavior in a familiar context may simply be forgotten. Ronis [74] pointed out that it may be particularly difficult to remember to perform novel behaviors in familiar settings because behavior in such settings is largely habitual and automatic. Habit is strongly rooted in behaviorist approaches to learning theory [93]. These habits proceed efficiently, effortlessly and unconsciously. When a habit develops, behavior is said to come under the control of stimulus cues [93] [68] [74]. On future occasions, presence in a similar situation is sufficient to trigger the automatic response sequence. A stable context is therefore crucial for habitual behavior to occur. In fact, habit has been defined as the tendency to repeat past behavior in a stable context [68]. Modern habituation perspectives follow Hull’s [48] reinforcement theory of learning. According to the theory, learning occurs in terms of automatic habits established through reinforcement. The relationship between habit and behavior is further empirically supported by Triandis’ Model [89].

**RESEARCH MODEL AND HYPOTHESIS**

**Research Model**

We aim to investigate IS continuance behavior to contribute to the growing interest in IS continuance and given the importance of IS continuance. Due to the need of research into the continuance of mobile Internet services, the latter is the chosen context. Therefore, IS continuance and IS continuance intention are the behavioral and behavioral intention variables of interest. Our model reflects our agreement with Bhattacherjee’s [20] argument on the substantive differences between the IS adoption stage and post-adoption stage by proposing variables different from those used in adoption models. We developed our behavioral model based on the theoretical framework proposed in the previous section.

Figure 1 illustrates the rational decision making and automatic behavior integrated model. In identifying the variables influencing user’s continuance behavior, we took into consideration the fact that the consumer, in the mobile Internet context, is bearing both the role of buyers and users [57]. Rather than enumerating all possible variables, we identified and selected the most salient cognitive as well as affective factor that captures most of the users’ behavior. Usefulness is, therefore, our selected cognitive factor in our continuance usage behavior model. In product-consumption-elicted experience, affect is important [69] [63] [51]. The definition of attitudes, on the other hand, has been more ambiguous with some researchers considering it strictly as an evaluative judgment rather than an affective state [28] and some considering it as both affective and cognitive [15]. However, in this research, we split human behaviors into cognition and affect. Therefore, emotion is the chosen affect construct. From the consumer choice perspective, consumers estimate the value of the choice object by considering all relevant benefit and sacrifice factors [49] [65] [88]. Value represents an overall estimation of the choice object. Given that end users’ perceived value is the consumer’s overall assessment of the utility of a product [97], perceived value is the chosen judgmental construct. In addition to these constructs, frequent usage of mobile Internet services involves habitual behaviors such as repeatedly typing similar words on the mobile phone keyboard. Habit, the construct in question, predicts IS continuance behavior. The mapping between the theoretical framework and the model is as follows: Affect is mapped onto emotion; cognition onto usefulness; judgment is reflected as perceived value; behavioral intention is mapped onto continuance intention; the behavior is Continuance usage and habit is habit.
Hypotheses

Usefulness is defined as the degree to which a person believes that using a particular system would be advantageous in performing his or her task [30] [29]. In our study, a task is an objective or function to be attained or performed using mobile Internet services. These tasks include using m-commerce to purchase movie tickets, checking mails as part of m-communication services and accessing contents off the m-Internet such as checking out the latest stock prices. Perceived value, on the other hand, is defined as the customer’s overall assessment of the utility of mobile Internet services based on the perception of what is received and what is given [97].

Karahanna [50] found that usefulness influences attitude (judgment) substantively and consistently. In our model, judgment is conceptualized as perceived value. Thus if a technology performs up to expectation, provides gains over alternative services and helps consumers in difficult situations (i.e. useful), consumers are likely to evaluate the use of the technology favorably. Similarly, as it improves on its ability to deliver convenience, effectiveness and efficiency in performing tasks, mobile Internet services appeal more to consumers, especially if the consumer is traveling. We therefore hypothesize:

H1: The usefulness of mobile Internet services is positively related to its perceived value.

Continuance intention is defined as the actual intention to continue using mobile Internet services in the post-adoption stage [20]. Originating from social psychology, Action Theory e.g. [40] and Work Motivation Theory e.g. [94] are the two main theoretical underpinnings for the usefulness and behavioral intention relationship. Work motivation theory specifies that task specific plans guide behavioral intention by linking instrumental acts to goals. Action identification theory [92] posits that an organized cognitive representation of action which is seen as a basic mechanism by which people cognitively regulate their behavioral intention in furtherance of higher level goals. These two theories share the view that the extrinsic motivation for engaging in specific behaviors stems from a mental representation linking instrumental behavior to higher-level goals or purposes. IS usage can be the means (behavior) to that end (goal). Following this line of thought, if an individual believes that the continued usage of an information system will help in attaining certain goals (i.e. useful), then that individual will intend to continue using it. Similarly, we expect users to intend to continue using mobile Internet services if they believe that using it will help them achieve certain goals, such as convenience benefits, not attainable in alternative means such as a physically stationary computer. Hence we hypothesis:

H2: The usefulness of mobile Internet services is positively related to the continuance intention

Emotion is defined as a mental state of readiness that arises from cognitive appraisals of events or thoughts, is often expressed physically (e.g. facial features) and may result in specific actions to affirm or cope with the emotion [13]. Sweeney and Soutar [85] defined emotional value, one of the multiple dimensions of value, as the utility derived from feelings or affective states that a product generates. Consistent with the definition of emotional value, individuals experiencing immediate pleasure or joy from using mobile Internet services are more likely to use it more extensively than others [30]. Hence we hypothesize

H3: The emotion generated from the usage of mobile Internet services is positively related to the perceived value

The definition of perceived value compares benefits with sacrifices [97]. This definition reflects the economic theory of utility whereby customers try to achieve maximum utility given their resource limitations. Perceived value, evaluative in nature, is similar in certain aspects to attitude in Davis’ TAM [29] which is used for explaining adoption intention in organizational context. We argue that the similar treatment of perceived value as a trade-off between the “give” and “get” components of a product [33], allows it to be used to explain consumers’ continuance intention. Perceived value is the consumer’s overall assessment of the choice object [97] from which consumers decide their choice behavior [49] [65] [88] [97] [52] have taken the first step to examine and confirm the relationship between perceived value and behavioral intention. In addition to their empirical studies, there is strong support that perceived value affects behavioral intention [86]. Hence we posit

H4: The emotion generated from the usage of mobile Internet services is positively related to the continuance intention

Behavioral intentions are instructions people give to themselves to behave in certain ways [91] and continuance intention is defined as the actual intention to continue using

Figure 1: Integrated Rational Decision Making and Automatic Behavior Continuance Model
mobile Internet services in the post-adoption stage [20]. Continuance usage, on the other hand, is the continuous usage of a system [61]. The relationship between intention and behavior is well-known in the literature [40] [90] [47]. Theories that support this relationship include TRA [40], TPB [1] and Triandis model [90]. In these theories intention to act or not to act is regarded as the immediate determinant of the action itself [47]. Therefore, we posit that,

**H6: The continuance intention of mobile Internet services is positively related to the continuance usage**

Habit is defined as the behavioral tendency to repeat responses given a stable supporting context [68]. In a stable context, responses become automatic requiring little or no cognitive processing. The habit-behavior relationship is founded in Hull’s reinforcement theory of learning [48]. Numerous researchers have explored and proven the causal link between habit and behavior. e.g. [10] [18] [19] [42] Habitual behaviors unfold in response to environmental events, often without the formulation of any conscious intent to engage in a specific sequence of action. Habitual behaviors may not likely have access to specific intentions and may appear to the actor to be unintentional and non-volitional. In other words, under the presence of habit, behaviors proceed automatically. Therefore, we hypothesize that

**H7: The habit of using mobile Internet services is positively related to the continuance usage.**

**RESEARCH METHODOLOGY**

In this section, we will present how we developed the scales for our constructs and how we conducted the survey. The items used to measure the constructs are adopted and adapted from existing validated scales. All measurements have been further checked for reliability and validity, as we will report later.

**Instrument development**

To measure usefulness, we adapted the scale of usefulness from Davis [30]. Emotion items were adopted from Cheung [27] and Cohen and Areni [28]. We adopted the scales for perceived value from Sirdeshmukh, Singh and Sabol [82]. Since perceived value means the comparison between cost and benefit, our scales compares fee and value, effort and benefit, and, time spent being worthwhile and overall good value. Continuance intention scales were adopted from [20]. To measure continuance usage, [60] first measured continuance intention and one month later measured usage for the same subjects. However, due to time constraint, we were only able to measure usage at the same time when continuance intention was measured. We used the seven-point Likert scale (1 = strongly disagree, 7 = strongly agree) in developing our questionnaire.

Two information systems researchers and five scholars reviewed the instrument and checked the face validity of the items. As a pre-test, the questionnaires were discussed during the interviews of 10 people (some of them had used mobile Internet services before and others had not). We obtained feedback about the content of the instrument, question ambiguity, the format of the scales, and its length and overall format and design of the questionnaire. The respondents were also asked to identify factors not in the questionnaire that they considered important and to describe their judgment related to the use of mobile Internet services. The final list of items, shown in Appendix A, for each construct reflects the feedback received.

**Data collection**

Empirical data for this study was collected via an Internet survey after which further data was collected by quota sampling, to recruit respondents above 25 years old, through face-to-face and mail questionnaire surveys. Emails were sent out via the University emailing list to the undergraduates and graduates of a major university in Singapore inviting them to take the survey if they have previously used mobile Internet services. The email recipients were encouraged to spread the word about the survey. To improve the response rate, $50 was offered to 20 respondents who were randomly selected for the prize. Confidentiality of responses was assured, and, prior to starting the survey, respondents were reminded only to take the survey if they have experiences using mobile Internet services. The first page of the questionnaire stated clearly who can be considered as having mobile Internet services experiences.

A total of 376 responses were collected. Out of the 376 responses, 4 were duplicates and 5 were found to have no previous mobile Internet services experiences. These were removed from the data set. Responses from respondents who overlooked the reverse order of items (intention item), for example, by saying they strongly agree to both continue using mobile internet services as well as discontinue its use, were discarded. To reduce cases of misuse or abuse of the survey, data from respondents who provided similar values to all or most of the questions were also removed. After cleaning the data, 324 responses were left.

**Demographic Profile**

The respondents’ detailed descriptive statistics of their characteristics are shown in Table 2. 64.5% of the respondents are male while 76.5% of the respondents are aged 20-29 years old. Previous studies found technology users in Singapore are predominantly male [87] and that most mobile Internet users are in their 20s and early 30s [53]. Therefore, the fact that 64.5% of the respondents were male and 76.5% were in their 20s was acceptable. Due to the fact that a university mailing list was used, 66.3% were university respondents. The high penetration rate of mobile phones in Singapore was reflected in the percentage of users, 88.9%, using mobile phones to access mobile Internet services.

**DATA ANALYSIS AND RESULTS**

**Reliability and Validity of Instruments**

We carried out factor analysis to further assess construct validity. Principal components analysis with Varimax rotation was conducted. A total of 5 factors with eigenvalue greater than 1 were extracted. The Cronbach’s alpha for all factors are above 0.70.
than 1.0 have been identified. The factors explain 73.6% of the total variance. All the items have loadings greater than 0.5, with .662 the lowest loading, and are loaded on a distinct factor. When compared across factors, the items are found to load highest on their own factors. We note that items of habit and usage load onto one factor. This is due to the fact that habit represents frequently repeated past behaviors [68] and is thus inherently associated with usage behavior. Furthermore, most of the loadings on the target factors (18 out of 22) were in the excellent range (i.e. loadings more than 0.71).

We conducted confirmatory factor analysis (CFA) by creating a LISREL path diagram. To assess the model fit, the following indices and standards are applied: goodness-of-fit index (GFI) and normed fit index (NFI) greater than 0.90, adjusted goodness-of-fit index (AGFI) greater than 0.80 [44], comparative fit index (CFI) greater than 0.90 and root mean square error of approximation (RMSEA) lower than 0.08 for a good fit and lower than 0.05 for an excellent fit [22] [64].

Following recommended methodological procedures [44] [9], the measurement model in the CFA has been revised by dropping, one at a time, items sharing a high degree of residual variance with other items. This is to purge items that violate unidimensionality. We dropped three items: The second (HAB2) and fourth (HAB4) item of habit and the second (USE2) item of usefulness. HAB2 shares a high degree of residual variance with HAB3, HAB4 and HAB5. HAB4 shares a high degree of variance with HAB1 AND HAB5. USE2 shares a high degree of variance with USE1. In order to be consistent, these three items were dropped from further analysis. After these items were dropped, the CFA showed a very good model fit: GFI = 0.90, NFI = 0.97, CFI = 0.99, AGFI = .88, RMSEA = 0.052.

Convergent validity is the degree to which the items of a given construct are measuring the same underlying latent construct. There are three criteria to assess convergent validity. First, standardized path loadings, which indicate the degree of association between the underlying variable factor and each item, should be greater than 0.7 and statistically significant (t-value above 1.96 for alpha of 0.05 and above 2.56 for alpha of 0.01) [44]. Second, composite reliabilities, as well as Cronbach’s alphas, should be higher than 0.7 [66]. Third, the average variance extracted (AVE) for each factor should exceed 50 percent [41]. The figures in Table 4 show all path loadings to be greater than 0.7 except for EMO4 and HAB1 and all of them are statistically significant. All the reliability measures are above 0.7 and all the AVE values are above 0.5. Thus, convergent validity of all the items is established.

Discriminant validity means the degree to which the measures of two constructs are empirically distinct. As suggested by Anderson and Gerbing [9], we used Constrained Confirmatory Factor analysis to assess discriminant validity. Ordinary CFA is conducted for every pair of factors, after which the correlation is set to unity (1.0) and the model is tested again. We use χ2 difference test to compare the results between the constrained model and the original model. Discriminant validity is established if the χ2 difference is significant. In our pair-wise constrained tests, the χ2 differences are all significant. Hence, discriminant validity is established.

Prior to testing the hypotheses, we also conducted a Pearson correlation analysis. The simple correlations among the research variables are shown in Appendix B (a).

Hypotheses Testing

After the measurement instruments had been tested for validity and reliability, the Hypotheses were tested using LISREL. The fit indexes were satisfactory: normed χ² = 2.51, GFI = 0.90, NFI = 0.97, CFI = 0.99, AGFI = .88, RMSEA = 0.052. We examined the path significance of each hypothesis. The results are shown in Figure 2.

![Figure 2 Hypothesis testing results](image)

The testing results show that the two hypothesized path are significantly related to perceived value: usefulness (β=0.31, p<.001) and emotion (β=0.47, p<.001). Thus hypothesis H1 and H3 are supported. Usefulness (β=0.24,
p<.001) and perceived value (β=0.29, p<.001) are also found to significantly affect continuance intention. Therefore, H2 and H5 are all supported. The path from intention to usage (β=0.17, p<.001) and, hence, H6 is also supported. Habit is significantly related to usage (β=0.70, p<.001). Therefore, H7 is supported. However, the path from emotion to intention is not supported.

DISCUSSION AND IMPLICATIONS

Discussion of Findings

The relationship between emotion and behavioral intention has been previously tested and is empirically supported by past studies e.g. [52] [58]. So the insignificance of the emotion-intention relationship is not due to its inexistence or inappropriateness, rather, it has to be due to the context of the research. The reason why the relationship between emotion and intention in this study is not supported may be due to gender bias [36]. Only 35.5% of the respondents are female. Females are found to score highest on feelings and emotions and they are more likely to response spontaneously to their feelings unlike males [62]. From our results, the respondents are not prone to react unconsciously to emotions but will rather evaluate their emotions via the perceived value construct. Given that the majority of the respondents in our study are males, this result is in line with Majee’s and Hojat’s [62] findings. This research aimed to achieve two main objectives. First, in order to answer to critics of behavioral models and to develop a complete model that will predict behaviors under various types of situations [47], this study aimed to develop a comprehensive model of rational decision making and automatic behaviors. Second, this study aimed to research into mobile Internet services continuance to provide much needed insights to practitioners [23] [81]. We further discuss our findings in relation to these two objectives.

Rational Decision Making and Automatic Behaviors

Our results proved that it is feasible to integrate both rational decision making and automatic behaviors in one model. Although, the measurement of continued usage at the same point in time as the measurement of continuance intention prevented the precise capture of continued usage itself, it did not prevent testing the integration of rational decision making and automatic behaviors. Measurement of continued usage at the same point in time as continuance intention implies that current usage was the actual measured construct. However, going by the definition of continuance intention [20], if an individual had the intention to continue using a system, he will also have the intention of currently using the system. Continuance intention is a superset of intention. Therefore, we argue that the relationship between intention and usage will be stronger than the relationship between continuance intention and usage. Since the relationship between continuance intention and usage was supported, the relationship between intention and usage will be even more so. Therefore, we managed to fully test the rational decision making and automatic components of our integrated model.

Repeated behaviors have been found to pose difficulties for the theories of reasoned action and planned behavior [80]. Without habit, that is automated behaviors, the R2 of usage would have been only 0.21. R2 of usage is 0.59 when predicted by both intention and habit. That is, an integrated model of rational decision making and automatic behaviors help to increase the explanatory power of the model. This explains why reasoned-based only models fail to predict frequently practiced behaviors in stable contexts. Habit is a strong predictor of human behavior [60]. In situations where individuals do not rationally form an intention to act due to their actions being performed automatically, reasoned based models fail to predict behaviors. A behavioral model that leaves out habits will thus be ignoring an important aspect of human behaviors. On the other hand, TRA [40] and TPB [1] have successfully proven the existence of rational behaviors. Leaving out the rational element, that is evaluative judgment and planned intention, will likewise be ignoring an important aspect of human behaviors. The significant relationship between intention and usage from our results proves that intention still predicts behaviors through the rational decision making process. Furthermore, from the support of H1, H3 and H5, the judgmental evaluation of cognitive and affective factors and subsequent formation of intention from the judgment shows the indirect involvement of these factors on human behaviors occurring through the rational decision making process. The supported H2 shows the possibility of the direct effect of cognition on behavioral intention that proceeds consciously. Although our results were not able to prove the direct relationship between emotion and behavioral intention, it does not imply that this relationship does not exist. Another data collection with balanced number of males and females is required to test the existence of this relationship. Responding to Holbrook [47], this study has been able to develop and test a comprehensive model consisting of rational decision making and automatic behaviors. Human behaviors are affected by cognitive and affective factors that can be evaluated to form judgments and they are affected by habits too. Therefore, our study has been able to identify and integrate the processes of human behaviors as well as identifying the components of these processes.

Mobile Internet Services Continuance

The measurement of continued usage at the same point in time as continuance intention results in the actual measurement of usage. This is not appropriate for studying mobile Internet services continuance. To this end, we have developed an alternative model using the same constructs. This alternative model thus ensures the presence of both rational decision making and automatic behavioral processes. Although intention should not be used as surrogates for behavior, because of the inability to measure continued usage, we had to limit the prediction of continuance behavior to continuance intention in this alternative model. We replaced the relationship between behavioral intention and behavior by the relationship between behavior and behavioral intention (inverse). We explained our reasoning for hypothesizing this new relationship in the next paragraph.

Research in psychology indicates a reputed success of past behavior as predictor of future acts [10] [18] [42]. Triandis [90], in his model, found that frequency of past behavior is the best predictor of future behavior. Here, usage
is the past behavior and continuance intention represents the
future behavioral intention. Usage grants users with direct
experience that shape their feelings towards the IS [20]. Belk
[16] argued that the effects of our prior choice behavior
appear to be able to be incorporated into our behavioral
intentions part of the time. Any value generated from usage
provides immediate reinforcement of reasons that drives
intention via direct learning and habit formation [47]. Thus,
users’ experience from usage is crucial towards their
continuance intention. Recently, Limayem [61] predicted and
confirmed a positive relationship between initial usages and
IS continuance. The more a user likes or finds mobile Internet
services useful while using the services, the more the user will
use the services. And the greater his usage, the greater is his
intention to continue using mobile Internet services in the
future. Therefore we posit that: “The usage of mobile Internet
services is positively related to the continuance intention”.

Figure 3: Results of alternative continuance model

Figure 3 shows the results of the test of the alternative
model. Our findings indicate that adopters’ intention to
continue using mobile Internet services is influenced mainly
by their habitual usage, by their overall evaluation towards the
use of mobile Internet services and by the perception of how
useful the services are. The results show that the continuance
intention of predominantly male population is not directly
influenced by their emotion.

Current usage, which is strongly affected by habits (R2
= 0.60; \(\beta = 0.77\)), is found to be an important factor for
continuance intention. Behavior, in the presence of habit, is
dominated by automaticity [68]. The loop habit-usage-continuance intention and, subsequently, future
usage is a self-reinforcing vicious loop. Habit, which is
developed as a result of frequently repeated usage of mobile
Internet services, will result in the unconscious and automatic
usage of the service [68]. This increases the frequency of the
usage and the usage itself increases the continuance intention
[42] [3]. Subsequently, this intention results in further usage
[40].

Our results show that (continuance) intention is
significantly predicted by perceived value, our evaluative
judgmental construct. This relationship can be further
explained by the theory of utility whereby consumers strive to
achieve maximum utility, that is, consumers behave such as to
maximize the value they obtained from their act. Although
perceived value is not attitude, these two constructs share the
same judgmental nature. Attitude has been used as the
judgmental construct to predict usage behavior at the
organizational context and during the adoption stage [29]. Our
findings show that, at the individual context, perceived value
is an equally successful judgmental construct in the prediction
of continuance intention. Attitude has served well at the
organizational level, but because of the difference between an
individual and an organizational context [59], it will be
interesting if future research can test which judgmental
construct, perceived value or attitude, can better predict
intention at the individual level. It is worth mentioning that
consumer behavior (individual context) has been deeply
examined in terms of perceived value rather than attitude in the
marketing literature e.g. [34].

The influence of usefulness on continuance intention
can be further understood via the perspective of extrinsic
motivation [72] [79]. Extrinsic motivation refers to the
performance of an activity because it is perceived to be
instrumental in achieving valued outcome [31]. Usefulness is
an example of extrinsic motivation. From the motivation
perspective, usefulness influences continuance intention
through the reinforcement of the valued outcome. Since using
mobile Internet services fulfills their needs, it tends to heighten
users’ interest in continuing its usage so as to reinforce the
utilitarian benefits. Although, for the survey responses in this
study, the emotion-intention link is not supported, this
relationship is expected to hold for a more gender balanced
survey sample. It can then be similarly understood via the
intrinsic motivation perspective [72] [79]. The hedonic
benefits derived such as fun and enjoyment from using mobile
Internet services generate positive feelings of emotion and the
adopter hopes to re-experience these emotions by continuing
the usage.

Implications for researchers and practitioners

Our findings have contributed to the research domain in many
ways and have several implications to researchers. According
to Belk [16] and Holbrook [47], behavioral models should be
comprehensive and complete in order to be able to better
predict behaviors in various situations. There have been IS
studies that included both rational and automatic components
in their models, although not explicitly stated. However, to
date, there have been no existing studies in the IS literature
that attempted to classify into, explain and to break-down the
components of rational decision making and automatic
behaviors. This study provides evidence that continuance
behavior can be explained by rational decision making and
automatic behavioral processes. The results indicate that
human behavior researchers need to consider both rational
decision making components as well as automatic behavioral
components in their models. Not only did this study develop a
rational decision making and automatic behavioral framework,
it developed and tested a continuance model based on the
framework for mobile Internet services. Distinct from prior
research on IS continuance e.g. [20] [60] our study suggests
that perceived value can be used to predict continuance
intention. Besides perceived value, the results have also
shown that there are cognitive and affective factors that can
help us better understand continuance intention. Our findings
also show that attention need to be paid to habitual usage in
order to better understand IS continuance. This suggests that
all these components need to be explored in IS continuance
studies. Furthermore, specific cognitive and affective
variables that are most salient in mobile Internet services
continuance have been identified. Hence, we have proposed
usefulness to be the cognitive variable and emotion to be the affective variable.

Our findings have profound practical implications for mobile Internet services providers. Since usefulness is found to influence the perceived value of mobile Internet services and the continuance intention, service providers can gather feedback to find out what are the services that consumers value more and find more useful. This will enable new and useful services to be updated constantly, keeping customers in a loop of services. In addition, this will enable service providers to focus on the most revenue generating services. Other than improving instrumental consumption experience, service providers should also improve emotional experience of consumers. Since adopters are found to evaluate their emotions contributing towards a higher perceived value of mobile Internet services, service providers may have to offer services that elicit positive emotions such as pleasure so that these feelings are used for their information value [71]. Therefore, service providers should either try to generate positive emotions in their services or provide more of these types of services. Our findings show that habitual usage contributes towards continuance intention. Encouraging frequent usage of mobile Internet services to the point that this usage becomes habitual [68] is thus essential for customers to continue using the services. One possible way is to provide free or cheap trials over a period of time long enough to induce habits. However, our literature review on mobile Internet services showed that those who tried the services during promotions discontinue their usage after the promotions [81]. From the light of our findings, we argue the main reason for their discontinuation is that the length of the promotion was not long enough and the conditions not appropriate enough to induce automatic usage of the services. Therefore, service providers should develop promotions over an appropriate length of time and such promotions should encourage frequent usage of the services so that consumers will develop the habit of using these services.

Limitations and Recommendations for Future Research

We acknowledge that a number of limitations exist in this study. First, since “emotional responses are not always recallable” [35], answering emotions-related questions via a survey questionnaire may not yield accurate results. Furthermore, due to time constraint we were unable to conduct further quota sampling to make sure that our sample was not gender bias [36]. Second, although we followed the age group distribution of mobile Internet users from other countries, the sample may be biased because most of the respondents are undergraduate students. Still, we cannot claim that the age group distribution from other countries resembles that of Singapore. This may restrict the generalizability of the findings. Third, respondents were motivated by monetary rewards to encourage response rate. Although we cleansed the data prior to data analysis, the data records may still contain careless responses from individuals who have no concern about research integrity. Fourth, due to time constraints, we were unable to measure continued usage. We were only able to measure usage at the same point in time as continuance intention was measured.

We have several recommendations for future research. First, to increase the generalizability of the results, the study needs to be replicated across diverse contexts, such as various countries. Second, we suggest using an experimental study to capture subjects’ emotions towards mobile Internet services as soon as they are experienced. This will minimize distortion posed by time on emotions recapitulation. Also, future research should strive for a balance in the gender of respondents. Such study would then be able to test the emotion-intention relationship. Third, a longitudinal study should be conducted in order to be able to measure continued usage. Fourth, research should be conducted to identify which behavioral mechanisms prevail in which conditions. Future research can also be conducted to identify any potential antecedents of habit and any relationship between habit and other variables.

CONCLUSION

One of the goals of this paper is to develop a rational decision making and automatic behavioral framework that will be comprehensive and complete. Existing theories and findings were identified and used towards that end. We showed that such integrated model has more explanatory power than just a rational decision making model. The second goal was to use this framework to develop a model for IS continuance of mobile Internet services. We tested our model and framework and provided recommendations to researchers and practitioners. By identifying ways practitioners can encourage the continuance of mobile Internet services, this study can help towards the success of this rising industry.

APPENDIX A. Measurement Instrument

<table>
<thead>
<tr>
<th>Variable</th>
<th>Item</th>
<th>Description</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuation intention</td>
<td>INT1</td>
<td>I intend to continue using mobile Internet services in the next six months</td>
<td>Bhattacharjee 2001</td>
</tr>
<tr>
<td></td>
<td>INT2</td>
<td>I expect my use of mobile Internet services to continue in the future</td>
<td></td>
</tr>
<tr>
<td></td>
<td>INT3</td>
<td>During the next six months, I plan to continue using mobile Internet services</td>
<td></td>
</tr>
<tr>
<td></td>
<td>INT4</td>
<td>If I could, I would like to discontinue my use of mobile Internet services</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EMO1</td>
<td>Unsatisfied - Satisfied</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EMO2</td>
<td>Annoyed – Pleased</td>
<td></td>
</tr>
</tbody>
</table>

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616
### APPENDIX B. Correlation Table

<table>
<thead>
<tr>
<th></th>
<th>EMO</th>
<th>USE*</th>
<th>VAL</th>
<th>HAB**</th>
<th>INT</th>
<th>IUL</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMO</td>
<td>.95</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USE*</td>
<td>.41</td>
<td>.96</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VAL</td>
<td>.55</td>
<td>.46</td>
<td>.95</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HAB**</td>
<td>.43</td>
<td>.36</td>
<td>.45</td>
<td>.93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INT</td>
<td>.36</td>
<td>.40</td>
<td>.46</td>
<td>.36</td>
<td>.95</td>
<td></td>
</tr>
<tr>
<td>IUL</td>
<td>.32</td>
<td>.35</td>
<td>.38</td>
<td>.66</td>
<td>.41</td>
<td>.95</td>
</tr>
</tbody>
</table>

**Note:** Leading diagonal shows the squared root of the AVE of each construct
* USE2 has been dropped
** HAB2 and HAB4 have been dropped

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CAUSAL RELATIONSHIPS AMONG LEISURE, BUSINESS TRAVEL ARRIVALS AND TOURISM DEVELOPMENT: EMPIRICAL EVIDENCE FROM KOREA

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ABSTRACT

This study examines the causal relationship between leisure, business travel arrivals and tourism growth in Korea. The Granger causality test is performed in order to reveal the direction of causality between tourist arrivals by different purpose and tourism development. Test results indicate that 1) a long-run equilibrium relationship between leisure and business travel arrivals exists, 2) a short run bi-directional causality between leisure travel arrivals and tourism growth exists, and 3) the growth of leisure travel arrivals is the catalyst for the growth of business travel arrivals. A discussion follows and managerial implications are identified based on the empirical findings.

Keywords: Leisure travel arrivals, business travel arrivals, tourism development, economic growth, Granger causality, Korea

INTRODUCTION

One global development during the recent world economic downturn has been the recognition of the tourism industry as a valuable national resource. The tourism industry has potential to incur positive economic, social and cultural effects. Effects include promotion of the national culture, vitalization of the local economy, as well as increased employment opportunities and disposable income. The tourism industry has been recognized as one of the new driving forces of economic growth. The importance of this industry directly results from the fact that it serves as a primary source for generating revenues, employment, private sector growth, and infrastructure development for many countries [1].

Through these benefits, tourism development not only stimulates the growth of the industry, but also triggers overall economic growth. Hence, boosting economic growth by developing the tourism industry has been frequently adopted as an important economic development strategy by many countries. Along with the increasing importance of the tourism industry for a country's economy, the issue of exploring the causality relationship between tourism development and economic growth has gained more academic attention.

Given the aforementioned reasons, Korea has been especially eager to promote tourism. Although Korea's rapid economic growth has been a result of an export-led economy, the tourism industry may be another contributing factor toward Korea's recent economic growth. According to the tourism research economic data of the World Travel and Tourism Council in 2009 [2], tourism in Korea contributed about US$63.1 billion to the GDP, 7.6% of the total economy. The tourism industry in Korea also supports about 8% of the total employment. Visitor exports, including expenditures by international visitors on goods and services within the economy, reached US$13.8 billion, which was 23.4% of the total exports in 2009. International visitors’ spending includes both travel spending and spending on transportation as well as hospitality services. This spending takes into account tour, business, education, and diplomat arrivals as well as other arrivals (i.e. visiting friends and relatives, conference convention arrivals, etc.).

The Korean government has recently noticed the crucial role of tourism development in the path of green economic growth and is eager to promote its tourism internationally. The Green Growth Initiative is a policy that emphasizes environmentally sustainable economic progress to foster low-carbon and socially inclusive development in Korea. “Visit Korea Year 2010–2012,” is a campaign for introducing the elegance and flavor of Korea to international tourists and was introduced as part of the green growth plan.

The aim of the campaign is to establish Korea as one of the most popular tourist destinations in the world. The Korea Culture and Tourism Institute (KCTI) publishes short-term international arrivals to Korea on a monthly basis. The data is collected from passenger cards that international visitors complete upon arrival into Korea. This card requests information including the purpose of the visit, demographics and trip details. According to a recent report of KCTI, total arrivals into Korea grew 57% from August 2005 to August 2010. Tour arrivals grew 57% during the same period while other arrivals also have grown significantly during the period (Figure 1).

Tour arrivals refer to international visitors who specified “sightseeing” on their passenger card as their primary reason for traveling. Business arrivals refer to international visitors who specify “business” as their primary reason for traveling. Business travel comprises of business, work travel for transport crews, attendance at conferences, conventions, exhibitions, trade fairs, seminars, incentive group meetings, marketing events as well as training and research related to short-term employment. Education arrivals refer to international visitors who specified “education” on their passenger card as their primary reason for traveling.

Figure 1. Trends of international visitor arrivals by purpose of visit

![Figure 1. Trends of international visitor arrivals by purpose of visit](image-url)
Tourism growth as a result of tour promotions tends to occur when tour arrivals demonstrate a stimulating influence across the tourism industry and the overall economy. However, results of the empirical studies of the causality between tour events arrivals and overall tourism growth have been mixed in tourism literature. Accordingly, research results for the relationship between tour promotion and tourism growth are still inconclusive. Therefore, providing further evidence for generalizing research results will make a substantial and novel contribution to the literature. Since economic growth in Korea may also attract additional business travel arrivals, inductive logic suggests that business travel arrivals lead to tourism growth.

Consequently, it is hypothesized that the business events arrivals into Korea can be a strong causal component of tourism growth, contrasting the presumption that tour events arrivals drives tourism growth. This study performs a cointegration analysis to look for the existence of a long-run relationship and Granger causality tests between leisure travel arrivals, business travel arrivals and tourism growth in the short-run.

LITERATURE REVIEW

Analyzing the relationship between economic growth and tourism development has been a popular topic in recent tourism literature: [1] [3] [4] [5] [6] [7] [8] [9] [10] [11] [12]. However, researchers have reached mixed and sometimes conflicting results despite the common choice of time series techniques as the research methodology. Extending from the export-led economic growth hypothesis, Balaguer and Cantavella-Jorda [3] reported that the tourism-led economic growth hypothesis holds true. However, Oh [11] found no long-run equilibrium, but a one-way causal relationship for economic-led tourism growth in Korea. Using similar methods but a different proxy (leisure travel arrivals) for tourism development, Kim et al.'s [7] study yielded opposite results from Oh's. They found long-run equilibrium and bi-directional causality between economic growth and tourism development in Taiwan. Considering that Taiwan and Korea are similar in terms of export-led economic growth and tourism's role in the economy, in particular business arrivals, such conflicting results are unexpected.

Treating tourism as a single industry with similar goods and services could be one reason for the inconsistent results among existing studies. Since international visitor arrivals could have different relationships with tourism development, the overall relationship between visitor arrivals and tourism development could be influenced by the weight and strength of the link between tourism development and the growth of international visitor arrivals sectors. These visitor arrivals may influence or respond differently to the same economic events in terms of timing and magnitude due to the difference in their offerings.

Though there is no empirical study that examines directly the relationship between visitor arrivals and tourism development in the industry level, Uysal and Gitelson’s study [13] and Chen’s study [14] could provide an indication of the interaction between tourism events performances and tourism growth. Consequently, when the tourism related industries are pooled together, they might interact with the overall economy as a portfolio, whose overall performance is subject to the weights and performance of individual sectors. This in turn could cause the directional relationships between the portfolio of visitor arrivals and overall tourism growth to be unstable across countries since the weights and performance of individual visitor arrivals could be different.

Therefore, investigating the relationship between leisure travel arrivals and tourism growth on the sub-industry level could generate more precise outcomes on the causal dynamics between tourism promotion development and tourism growth. In addition, since extant studies have focused on the relationship between overall tourism growth and economic development, this study also fills a research gap in the literature by investigating the direction of the causality on the sub-industry level. Accordingly, the following hypotheses are considered:

Hypothesis 1: There is a long-run equilibrium relationship between leisure travel arrivals, business travel arrivals and tourism growth.
Hypothesis 2: The growth of leisure travel arrivals causes tourism growth.
Hypothesis 3: The growth of business travel arrivals causes tourism growth.
Hypothesis 4: The growth of business travel arrivals causes the growth of leisure travel arrivals.
Hypothesis 5: The growth of leisure travel arrivals causes the growth of business travel arrivals.

RESEARCH METHODOLOGY

Data

The most common unit of measure used to quantify the volume of international tourism for statistical purposes is the number of international visitor arrivals. For a proper understanding of this unit, two considerations should be taken into account: 1) Data refers exclusively to overnight visitors- a visitor who stays at least one night in a collective or private accommodation in the country visited, 2) Data refers to the number of arrivals and not to the number of persons (the same person who makes several trips to a given country during a given period will be counted as a new arrival each time).

Figures on the volume of international tourism presented preferably relate to the concept of international visitor arrivals.

This study employs monthly time series data from January 2005 to August 2010 (68 observations). Based on data availability, the data on the output of total arrivals is used as a proxy of overall tourism growth, the number of tour events arrivals is used as a proxy of tour arrivals, and the number of business events arrivals is used as a proxy of business arrivals. The information about overall leisure travel arrivals and purpose of their visit were obtained from the travel and tourism knowledge information database of the Korea Culture and Tourism Institute (KCTI, http://stat.tour.go.kr/). The time series are seasonally unadjusted and, therefore, transformed in natural logarithm to minimize any possible distortions of dynamic properties of the data.
### Unit Root Test

To ascertain the order of integration of the variables, this study applied the Augmented Dickey-Fuller (ADF; [15]) unit root test and the Phillips–Perron (PP; [16]) test. ADF and PP tests are carried to test the null hypothesis of a unit root in the level and the first difference of the variables. As Enders [17] indicated, the ADF test assumes the errors to be independent and have constant variance, while the PP test allows for fairly mild assumptions about the distribution of errors. Results of both ADF and PP tests for stationarity are reported in Table 1.

<table>
<thead>
<tr>
<th>Variable</th>
<th>ADF t-statistic (lag length)</th>
<th>PP t-statistic (bandwidth)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tourism growth</td>
<td>-2.263</td>
<td>-10.062*** (0)</td>
</tr>
<tr>
<td>Tour arrivals</td>
<td>-2.472</td>
<td>-7.404*** (3)</td>
</tr>
<tr>
<td>Business arrivals</td>
<td>-4.458***</td>
<td>-8.846*** (3)</td>
</tr>
</tbody>
</table>

Note: **ln** denotes the natural logarithm of the variable under consideration. Δ denotes the first difference of the variable under consideration. The test equations were tested by the method of least squares. The ADF and PP test equations include an intercept but no time trend in the model. For both the ADF and PP t-statistics, the probability value for rejection of the null hypothesis of a unit root are employed at the 1% level (***, p-value < 0.01) and the 5% level (**, p-value < 0.05) based on MacKinnon [27] one-sided p-values.

### Cointegration Test

Time series variables may be cointegrated if there exists one or more linear combination among the variables. If these variables are cointegrated, then there exists long run equilibrium among the variables. In other words, if the variables are cointegrated there is a long-run relationship and there exists a force to converge into long-run equilibrium. There are two test methods to identify whether there exists a cointegrating relationship among variables. They are (a) the Engle-Granger single equation test method [19] and (b) the Johansen-Juselius cointegration test [20]. Though the Engle-Granger method suffers from some shortcomings [21], this study applies the Engle-Granger method as a diagnostic purpose to test the null hypothesis of a unit root for the residuals of cointegration.

All variables that have been used in the model reported as overall tourism growth (TG), tour events arrivals (TOUR) and business events arrivals (BIZ) are integrated of order one I(1). The results of the Engle-Granger single equation test in Table 2 indicate that the null hypothesis of a unit root can be rejected at the 5% significance level (Table 2). In other words, series are cointegrated. Therefore, this study concludes that long-run equilibrium does exist between leisure travel arrivals, business travel arrivals and tourism growth.

Cheung and Lai [22] report that the Johansen approach is more efficient than the Engle and Granger single equation test method because the maximum likelihood procedure has good large and finite sample properties. Johansen [23] [24] considers a simple case where a time series is integrated of order one I(1), such that the first difference of a time series is stationary. The Johansen cointegration test models each variable (which is assumed to be jointly endogenous) as a function of all the lagged endogenous variables in the system. To illustrate the unrestricted VAR cointegration test of Johansen, consider a general VAR model written in the error correction form with Gaussian errors.

The null hypothesis of a unit root cannot be rejected in the level of the variables, except the business arrivals, but all null hypothesis of a unit root is rejected in the first difference of the variables. The results in Table 1 unanimously confirm that all variables are integrated of order one I(1). The optimal lag in the ADF test is automatically selected based on the Schwarz Info Criterion (SIC) and the bandwidth for the PP test is selected based on the Newey-West estimator [18] using the Bartlett kernel function.

The results of the Johansen cointegration test in Table 2 show that the two likelihood ratio test statistics are larger than the critical values; therefore, the null hypothesis of no cointegration can be rejected at the 5% significance level. The results in Table 2 indicate that there exists at least one cointegrating relationship between leisure travel arrivals, business travel arrivals and tourism growth in Korea.

Therefore, this study concludes that Hypothesis 1, “There is a long-run equilibrium relationship between leisure travel arrivals, business travel arrivals and tourism growth,” is supported. There exists a cointegrating relationship between tourism promotion development and tourism growth in Korea. In this case, the Granger causality test method (Granger, 1988), the unrestricted VAR model with the first differenced variables, is not the best option for testing directional causality of short run dynamics.
Table 2. Results of Cointegration test

<table>
<thead>
<tr>
<th>Model</th>
<th>Tau-Granger method</th>
<th>Johansen cointegration test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Z-statistic</td>
<td>Trace test</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maximum Eigenvalue test</td>
</tr>
<tr>
<td>F(TG/TOUR, BIZ)</td>
<td>-3.186 (0)</td>
<td>35.289**</td>
</tr>
<tr>
<td></td>
<td>-18.160</td>
<td>24.589**</td>
</tr>
<tr>
<td>F(TOUR/BIZ, TG)</td>
<td>-3.247 (0)</td>
<td>10.700</td>
</tr>
<tr>
<td></td>
<td>-19.217</td>
<td>8.945</td>
</tr>
<tr>
<td>F(BIZ/TOUR, TG)</td>
<td>-4.471** (0)</td>
<td>1.754</td>
</tr>
<tr>
<td></td>
<td>-29.225**</td>
<td>1.754</td>
</tr>
</tbody>
</table>

Note: The test equations were tested by the method of least squares. For the Engle-Granger single equation test method, the model includes intercept (no trend). The optimal lags are automatically selected based on the Schwarz Info Criterion and are in parentheses. The probability value for rejection of the null hypothesis of a unit root is employed at the 1% significance level (***, p-value < 0.01) and the 5% significance level (**, p-value < 0.05) based on MacKinnon (1996) one-sided p-values. For the Johansen cointegration test, the regression model allows for linear deterministic trend in data and include intercept (no trend) in VAR. For the two likelihood ratio test statistics, the probability value for rejection of the null hypothesis of no cointegration is employed at the 0.05 level (**, p-value < 0.01) and (***, p-value < 0.05) based on the MacKinnon-Haug-Michelis [28] p-values.

Granger Causality Test

Engle and Granger [19] and Granger [25] note that if the variables are cointegrated, there always exists a corresponding error correction representation in which the short-run dynamics of the variables in the system are influenced by the deviation from equilibrium. The cointegrated variables must have an error correction representation in which an error correction term must be incorporated into the model. Accordingly, a Vector Error Correction Model (VECM) is formulated to reintroduce the information lost in the differencing process, thereby allowing for long-run equilibrium as well as short-run dynamics. The VECM implies that changes in one variable are a function of the level of disequilibrium in the cointegrating relationship (captured by the error correction term), as well as changes in other explanatory variables. Thus, the VECM is useful for detecting the long-run and short-run Granger causality when the variables are cointegrated.

The VECM can distinguish between the short-run and long-run Granger causality because it can capture both the short-run dynamics between time series and their long-run equilibrium relations. The long-run causality is determined by the error correction term, whereby if it is significant, then it indicates evidence of long-run causality from the explanatory variables to the dependent variable. The long-run causality is implied through the significance of the t-statistic of the lagged error correction terms, which contains the long-run information because it is derived from the long-run cointegrating relationships. In this case, it estimates the asymptotic variance of the estimator, then the t-statistic will have asymptotically the standard normal distribution.

On the other hand, the short-run Granger causality can be tested by the Wald test. Under the Wald statistical test, the maximum likelihood estimate of the parameters of interest is compared with the proposed value, with the assumption that the difference between the two will be approximately normal. Typically the square of the difference is compared to a chi-squared distribution. The Block Exogeneity Wald test in the multivariate VECM system provides chi-squared statistics that are used to interpret the statistical significance of coefficients of the regressors. In this way, Wald test statistics (Note: Engle [26] showed that the Wald test, the likelihood-ratio test and the Lagrange multiplier test are asymptotically equivalent chi-squared distribution) can be used to find out the Granger causal affect on the dependent variable. Table 3 displays the results of Granger causality test by the Block Exogeneity Wald test.

Table 3. Results of Granger causality tests (Block Exogeneity Wald tests)

<table>
<thead>
<tr>
<th></th>
<th>“X” to</th>
<th>“Y”</th>
<th>Economic growth</th>
<th>Tour arrivals</th>
<th>Business arrivals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long-run equilibrium</td>
<td></td>
<td>Cointegrating</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>vector (ECT)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.313</td>
<td>2.319</td>
<td>4.763**</td>
<td></td>
</tr>
<tr>
<td>Short-run dynamics</td>
<td></td>
<td>Economic growth</td>
<td></td>
<td>17.596***</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tour arrivals</td>
<td>13.032***</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Business arrivals</td>
<td>1.140</td>
<td>0.420</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The coefficients of regressors have been estimated by VECM. Numbers in the cells of the independent variables (“X”) are chi-squared statistics and numbers in the cells of ECT are asymptotic t-statistics, which are used to interpret the statistical significance of the parameters. The probability value for rejection of the null hypothesis is employed at the 1% significant level (***, p-value < 0.01), the 5% significant level (**, p-value < 0.05) and the 10% significant level (*, p-value < 0.1), respectively.

Considering the results of the Granger causality test in Table 3, this study concludes that Hypothesis 2, “The growth of leisure travel arrivals causes tourism growth,” is supported, Hypothesis 3, “The growth of business travel arrivals causes tourism growth,” is not supported, Hypothesis 4, “The growth of business travel arrivals causes the growth of leisure travel arrivals,” is not supported, and Hypothesis 5, “The growth of leisure travel arrivals causes the growth of business travel arrivals,” is supported.

In other words, since there exists the bi-directional relationship between tour events arrivals and tourism growth, this finding suggests that tourism promotion development plays a significant role in forecasting tourism growth in the country. In conclusion, this finding suggests that tourism...
promotion development and tourism growth significantly reinforce each other in the economy. However, since there exists a one-way directional causality that runs from tour events arrivals to business events arrivals, this finding suggests that the leisure travel arrivals are promoting the growth of business travel arrivals in the economy.

**DISCUSSION AND POLICY IMPLICATIONS**

The finding suggests that there exists the bi-directional relationship between tourism development and tourism growth in the country. This study further detects that the growth of leisure travel arrivals plays a more critical role than tourism growth in leading the direction of causality and the leisure travel arrivals are promoting the growth of business travel arrivals as well.

Empirical findings in this study offer valuable information for tourism business managers and tourism policymakers. From the policy maker's perspective, it provides a good reference for timing and prioritizing the allocation of resources among industries for better overall tourism and economic outcomes. Since the bi-directional causal relationship between tour events arrivals and tourism growth exists, more resources should be allocated to the development of tourism promotion. To stimulate tourism growth, the development of tourism promotion appears to be essential. The most efficient strategy would be allocating more resources to the development of leisure travel arrivals because the contribution of business travel arrivals remains rather small. On the other hand, using enthusiastic promotion for leisure travel arrivals or a strategic plan to improve the tourism industry will be an effective way to boost the overall economy. From the tourism business manager’s perspective, the non-directional causal relationship between leisure travel arrivals and business travel arrivals suggests that there may not exist some potential value associated with bundling the services of these two sectors.

The results of this study also have several implications for academia. From the cointegration test, the long-run relationship between leisure travel arrivals and tourism growth indicates that tourism promotion contributes substantially to the overall tourism growth in the country. That is, mechanisms to boost the business activities of the tourism industry could be successful in the long-run. From the Granger causality test, the bi-directional causality between leisure travel arrivals and tourism growth may reflect a substantial contribution of the tourism promotion to the overall tourism growth in the short-run. The non-directional causality between business events arrivals and tourism growth may reflect a small contribution of business travel arrivals to the overall tourism industries in the short-run. By improving the business conditions of the tourism industry, the tourism industry could offer better services and goods, which may in turn strengthen the pull factors of the country as one of the best tourism destinations and eventually benefit the overall economy.

Although this study focuses on the causality between leisure travel arrivals and tourism growth, the aggregated visitor arrivals used for analysis included non-tourism arrivals, i.e. education arrivals and conference convention arrivals. For example, the education arrivals could generate a large portion of tourism receipts because education is usually a long-term consumption item and the tourism industry may benefit from students and passengers traveling to visit friends and families. However, the number of education arrivals tends to be less influenced than other categories by short-term tourism promotions. By segregating those sectors from total arrivals, the interactions between the outcomes of tourism promotion and the outcomes of leisure travel arrivals could be better understood. Such analysis could provide more specific, perhaps more useful, information for tourism managers and therefore a further investigation on the determinants of cointegration between the policies of tourism promotion and tourism growth is also suggested for future studies.

In conclusion, the significant outcomes of tourism promotion efforts to tourism growth are empirically documented in this study. This result also implies that the development of tourism promotion policies and programs can serve as an effective and efficient means to boost the growth of the overall tourism industry and overall economy in Korea. More general conclusions can be drawn if this research can be replicated with data from different countries since the long-run relationship and causality in the short-run between tourism promotion and tourism growth may be different from country to country.

**REFERENCES**


Factors Affecting Organizational Commitment of IT Staffs: An Empirical Study of IT Shared Service Center in Financial Institutions

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Abstract

South Korea enacted Financial Holding Company Regulations as new financial system for enhancing competitiveness according to rapid changes of global market. Since then companies have restructured their systems to financial holding company systems and integrated as single IT organization which previously existed under the each financial affiliate has also performed. In addition, adopting IT SSC (IT Shared Service Center) has been conducting for supporting IT services to each of affiliated companies of financial holding company. In recent years, many of financial companies, however, have several problems to adopt IT SSC. This paper, therefore, aims to investigate the factors related to organizational commitment to adopt IT SSC. In particular, we empirically conducted a survey study on financial institutions in Korea.

Keywords: IT Shared Service Center, Procedural justice, Distributive fairness, Mergers and acquisition, Reorganization

1. INTRODUCTION

In recent years, the global financial industry environment is becoming bigger and expanding its scope as a way of improving the competitiveness. Financial institutions realized an economy of scale by combining services such as banking, securities, insurance, etc. to have sustainable income structure and high profitability.

National financial industry established the financial holding company law as a new financial system in 2000 in order to improve its competitiveness in the fast changing world market. Based on this, each financial institution is going through a rapid transition to restructuring for an economy of scale and scope increase. After the law on financial holding companies was enabled, financial institutions in South Korea were restructured to financial holding company system which enables to become larger and also to have the scope increased. During this process, redundant IT departments from each financial subsidiary company were integrated and they reformed as IT Shared Service Center, which provides IT services to all the subsidiary companies.

In 2000, Woori Financial Holding Company integrated the IT departments of Woori Bank and Gyungnam Bank into the Woori financial information system. All of the IT departments within the financial group except for Woori Investment Securities were integrated as single service company which provides IT Shared Service. For IT department in Woori Investment Securities, it is still under negotiation with a labor union [8]. Other financial holding company, such as Financial Group, Shinhan Financial Holding Company, KDB Financial Holding Company, IBK Financial Group either have already adopted or are in working in progress of applying the IT Shared Service Center [8].

However, most of these financial companies that is in the middle of the implementation of IT SSC, they are commonly having difficulties with the existed IT employees who oppose to the implementation of IT SSC, due to the belief that the changes may have negative impacts on the IT employees. Besides, the companies that adopted the center did not achieve as much as expected particularly in terms of cost reduction, integrating IT professional service and improving the capabilities, not to mention the fundamental roles of IT SSC.

Moreover, this is caused by the negative perceptions on the application of IT SSC after and during its application, which negatively influenced on the integration of organization. Because of the same reason, it cannot draw the employees’ voluntary focus on the organization that leads to both individual accomplishment and the performance of IT SSC.

Therefore, this research study investigates the factors that have an influence on the organizational commitment in terms of the organization management in order to obtain expected effect from the implementation of IT SSC among the financial IT departments which has already adopted the IT SSC. It is expected that the outcome of this study would give an implication to organizations who have adopted or consider the implementation of IT SSC, regarding where to pay attention in terms of the organization management, in order to obtain the expected effect through the application of IT SSC.

2. LITERATURE REVIEW

2.1 Shared Service

2.1.1. Definition of Shared Service

In general, Shared Service can be defined as a business strategy to manage a part of non-strategic activities into a separate core business unit, integrating personnel, finance, information system, etc. that exist in every business units of a company, in order to have cost reduction to be competitive in the market [3]. This Shared Service focus on a part of business functions on a semi-autonomy industry unit that has an independent management structure from the parent company. This is a kind of collaboration strategy to promote the improvement of efficiency in the parent company, value creation, cost reduction and improving service quality [3].

In order to provide the better service with a lower cost to inside partners, it centralizes all the scattered resources around the company that were used for repetitive activities on a single task, sharing the common objective of increasing the company value as well as satisfying internal customers.
Shared Service can provide the better quality of service with the lower cost. Besides, because Shared Service Center is fully responsible for non-strategic work, the headquarter office can devote itself to activities strengthening the core capability. It can be maintained with a low number of staff so that it can significantly reduce the labor cost. By redistributing the Shared Service into an independent business unit, it also can create profits from external customers [5].

According to the research of Kearney [12], there was 14%-cost reduction in average in the world, such as 15% in North America, and 18% in Europe after the implementation of Shared Service. However, most of cost reduction comes from reducing work force, where 12% of cost was reduced by laying off work force.

### 2.1.2. IT Shared Service

Gunn et al. [10] stated that IT Shared Service is defined as a management concept to resolve the problems in non-hierarchical organizational structure and the management of scattered IT resources. Shah [19] also stated that IT Shared Service integrates all the services in the past that were individually handled in respective business unit.

In recent years, many companies in South Korea are in the process of introducing IT SSC, in order to reduce redundant IT resources and also to reduce the maintenance cost. Table 2-1 shows current progress of either implemented or implementing of IT SSC in Korea.

<table>
<thead>
<tr>
<th>Company</th>
<th>Establishment year</th>
<th>Number of affiliated company</th>
<th>IT affiliated company</th>
<th>Existent Circumstances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shinhan Financial Holding Company</td>
<td>2001</td>
<td>12</td>
<td>Shinhan Data System</td>
<td>Integrated operating</td>
</tr>
<tr>
<td>Hana Financial Holding Company</td>
<td>2008</td>
<td>8</td>
<td>HANA I&amp;S</td>
<td>Integrated operating and human resource</td>
</tr>
<tr>
<td>KB Financial Holding Company</td>
<td>2008</td>
<td>9</td>
<td>KB Data System</td>
<td>In the process making a plan about IT strategy</td>
</tr>
<tr>
<td>The Korea Development Bank</td>
<td>2009</td>
<td>5</td>
<td>None</td>
<td>Worrying about integration and making a IT affiliated company</td>
</tr>
<tr>
<td>IBK</td>
<td>In the</td>
<td>IBK</td>
<td>Integration</td>
<td></td>
</tr>
</tbody>
</table>

**Table 2-1** Current Status of the IT SSC implementation in financial sectors in Korea [8]

However, there are several challenges and difficulties while IT SSC implementation is progressing. This includes maintaining high quality of IT service due to increasing IT outsourcing from IT SSC, disappointed performances despite of improvement in organizational effectiveness and cost reduction, and the resistances of IT staffs’ against IT SSC implementation. Due to all of the reasons, the implementation of IT SSC is currently being delayed. Table 2-2 shows some of difficulties a company may face with regard to the adoption of IT SSC. In particular, the one of biggest challenges is the IT employees' opposition who will suffer from the organizational change from the application of IT Shared Service Center.

<table>
<thead>
<tr>
<th>Company (Affiliated company)</th>
<th>IT Affiliated company integrated status</th>
<th>Expected effect of Groups</th>
<th>Worrying of Groups</th>
<th>Common complaints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Woori Financial Holding Company (Woori Financial Informatin System)</td>
<td>2001 Woori Bank, KyungNam Bank, Gwangju Bank Integrated 3 banks’ human resource and launch the Woori Financial Informatin System</td>
<td>Cost savings through economi c of scale, IT cost-effec tivenes s and synergy, Improve IT service level</td>
<td>Resistan ce of people who work in IT departm ent, Expertis e and capabilit y</td>
<td>Even if integration planning capabilities , IT-led business innovation is not easy and they can be reduced to a simple subcontracting company</td>
</tr>
<tr>
<td>Hana Financial Holding Company</td>
<td>2007 HSBC life insurance, Hana capital, Integrated 2 companies’ human resource.</td>
<td>Cost savings, Improve IT service level</td>
<td>Resistan ce of people who work in IT departm ent</td>
<td></td>
</tr>
</tbody>
</table>

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Especially, the opposition of the members who will experience organization changes by introducing IT Shared Service Center is the biggest problem. There are good chances of delay in introducing IT Shared Service Center or being dissatisfied with the result of performance that was expected before introducing IT SSC. It is important to draw the organizational commitment and successful integration among the members in the integrated IT organization, in order to achieve the expected performance. For this, it is necessary to investigate factors that may have an influence on organizational commitment and to manage appropriately.

2.2. Organizational Justice

Organizational justice deals with a way to determine if employees are fairly treated in their positions and if the decision has an effect on other work-related variables [18]. Lind and Tyler [15] stated that organizational justice which focuses on the distributive fairness with regard to the performance compensation in early 1960’s did not account for people’s response about injustice, and that it is also critical to have a procedure to allocate the compensation for the performance. Accordingly, it began to recognize the importance of procedural justice that focuses on the procedure of distributing the accomplishment [6], [21].

2.2.1. Distributive Fairness

Distributive fairness in the organizational environment is closely related to the fairness that employees feel about distribution and compensation (for instance, wage increase, bonus, promotion, etc.). Distributive fairness focuses on one’s recognition of how fairly he/she receives the performance in terms of both quality and quantity compared with others who participated in the same project/work.

2.2.2. Procedural Justice

Procedural justice was initially introduced by Thibaut and Walker [21] and mainly focuses on legal proceedings [7]. Leventhal [14] expanded the application of procedural justice from legal proceedings to organizational environment.

Procedural justice means the justice in procedure to compensate for achievement [15].

If the procedure is not fair after achieving the desired result, members of organization would feel unfair. Accordingly, this will have a negative effect on each individual’s attitude and action. Therefore, procedural justice is similarly important as distributive fairness [15].

2.3. Treat of Job Security and Position Value

In recent years, there has been mergers and acquisitions, reorganization, and so forth that have an influence on employees, that would cause anxiety about their job security. One of the objectives of the IT SSC implementation is to reduce cost with job cuts. Hence laying off the IT staffs is inevitable in the process of restructuring and reorganization. This puts the employees to feel insecure about their jobs. In addition, even if job security is guaranteed, employees are to face a threat of value in their positions regarding a new position, an opportunity of promotion, career change, and so on, after the reorganization. The threat to the job and value in position not only have an adverse effect on employees but also result in the change of attitude such as voluntary resignation, low devotion to the organization, low work satisfaction [2], which directly leads to the performance.

2.4. Organizational Commitment

The organizational commitment is considered as an important element in explaining employee’s attitude and activity in the organization [17]. Organization commitment has an effect on the decision if an employee continues to work or stop working for the organization, and therefore shows the degree of equating himself/herself with the organization and that of how devoted the employee is to the organization.

Steers [20] stated that employees with higher organizational commitment had a lower rate of absenteeism, equated the objective and value of organization with theirs, and showed higher work performance. That is, once the organizational commitment is formed, each individual regards himself/herself to be important, which leads to have a positive effect on the performance of work.

3. RESEARCH MODEL & RESEARCH HYPOTHESIS DEVELOPMENT

3.1 Proposed Research Model

Previous research study shows that organizational commitment is required to have better performance in terms of organization among various expected benefits by implementing IT SSC, such as gaining synergy from integrating the organization to provide effective IT service, improving work productivity and enhancing IT specialty and quality. In order to have effective organizational performance, it is required to have employee’s organizational commitment first. Among many factors that have an influence on the organizational commitment, there are distributive fairness, procedural justice, a threat to losing the job and a threat to value in position as organizational factors that the employees would experience, after or during the IT SSC implementation.

This is related to the biggest challenge that IT employees will experience during M&A process. In addition, this is an area that can be controlled by the management of organization. Hence, it is necessary to investigate what employees experience in these regards and what influence these experiences will have on the sentimental organizational commitment.

Although faced with the difficulty in integrating the organization due to the resistance of IT employees against IT SSC, financial institutions are persuading employees with the effectiveness of IT Shared Service, by explaining them to change the employees’ perception on IT SSC personnel as a value creator not just as a supporter for IT functions. As a result of this, it needs to see how employees recognize IT SSC and if the perception of IT SSC has an adjusting effect between previously drawn independent variable and dependent variable. In order to verify this, the following research model was proposed as shown in figure 3-1.
3.2 Research Hypothesis Development

3.2.1 Organizational Justice & Sentimental Organizational commitment.
Organizational justice deals with a way to determine if employees are fairly treated in their positions and if the decision has an effect on other work-related variables [18]. Sentimental organizational commitment can be affected by organizational justice. The following are the research hypothesis in accordance with the organizational and sentimental organizational commitment.

H1: Fair distribution has a positive (+) influence on the sentimental organizational commitment.
H2: Fair procedure has a positive (+) influence on the sentimental organizational commitment.
H3: A threat to losing the job has a negative (-) influence on the sentimental organizational commitment.
H4: A threat to value in the position has a negative (-) influence on the sentimental organizational commitment.

3.2.1 Recognition of IT SSC
When members recognize benefit of introducing IT SSC their answer can be different from others who didn’t recognize benefit of introducing IT SSC. The following are the research hypothesis in accordance with the recognition of IT SSC

H1-1: The effect of fair distribution on the sentimental organizational commitment will vary depending on the recognition of IT SSC.
H2-1: The effect of fair procedure on the sentimental organizational commitment will vary depending on the recognition of IT SSC.
H3-1: A threat to losing the job will have a negative (-) influence on the sentimental organizational commitment.
H4-1: A threat to losing the job on the sentimental organizational commitment will vary depending on the recognition of IT SSC.

3.3 Operational Definitions and Development of Measurement items

In this paper, Distribution Fairness is defined as the degree of recognition in terms of compensation quality and quantity, that the employees are compensated for the work performance such as the work they put into, experience, education and training. Procedural Justice focuses on whether employees are fairly treated during the decision-making process regarding the personnel issue.

[Table 3-1] summarizes the operational definitions and measurement items about fair distribution and fair procedure.

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Operational definition</th>
<th>Measurement item</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distributive fairness</td>
<td>Distributive fairness which is recognized by staffs</td>
<td>Distributive fairness for role</td>
<td>[7]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Distributive fairness for career</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Distributive fairness for effort</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Distributive fairness for tension and stress from work</td>
<td></td>
</tr>
<tr>
<td>Procedural Justice</td>
<td>Procedural Justice which is recognized by staffs</td>
<td>Equality of principle which is applied to personnel evaluations</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Equality of standard which is applied to personnel evaluations</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Equality of staffs’ background which is applied to personnel evaluations</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Equality of former company which is applied to personnel evaluations</td>
<td></td>
</tr>
</tbody>
</table>

[Table 3-1] Operational definition and measurement items of Independent variable [4]

After the consolidation of organization for the work efficiency such as the change in organizational structure including merging, downsizing organization for the cost reduction, and mandatory reduction in the number of staff, employees are faced with a significant change in their lives, where they suffer from stress with an anxiety of becoming a scapegoat such as unemployment [2].

In this study, a threat to losing the job after merging organizations is defined as a threat to losing the job such as layoff. Likewise, a threat to value in position is a threat to the nature of valued work such as personal roles, the attributes of the given work, experience related issue, etc.

[Table 3-2] summarizes the operational definitions and measurement items of threat of job security and position value.

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Operational definition</th>
<th>Measurement item</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threat of job security</td>
<td>Treat of losing the job which is recognized by staffs</td>
<td>Threat of non-voluntary retirement</td>
<td>[9], [11]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Threat of retirement in the near future</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Threat of losing a job in the near future</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Threat of downsizing on a company scale</td>
<td></td>
</tr>
<tr>
<td>Threat of position value</td>
<td>Treat of value in position</td>
<td>Awareness of opportunity for career development from</td>
<td></td>
</tr>
</tbody>
</table>
In this study, organizational commitment has a wide influence on employee's life and attitude such as the intention of changing job, personal health problem including the stress at the job as well as the attitude relevant to the job including work satisfaction, work performance, and citizen behavior. In addition, as the employees have lower degree of organizational commitment while the organization is in the middle of change, it may lead to several side effects such as resignation, decline in work performance and work satisfaction, so that it needs to be specially taken care of. The organizational commitment puts employees in the same light as the organization they belong to and is defined as the degree of attachment that employees are willing to devote to the organization [1].

![Table3-2] Definition of variables such as a threat to losing the job and a threat to value in position[4]

The implementation of IT SSC is still understood as a factor that have an influence either positive or negative on the financial institution and companies providing services. This study suggested the definitions and measurement items about recognizing the effectiveness of IT SSC, as shown in [Table 3-4].

![Table3-3] Definition of variables such as a organizational commitment [4]

### 3.4 Research Methodology

This study will be conducted based on the survey of employees in IT department in financial institutions with the application of IT Shared Service Center. Using the Likert Scale (7 points), a questionnaire of total 24 questions will be prepared for about 10 days by mail, email, and online survey. The unit of analysis of this study will be set on personal level. The respondents of questionnaire are aware of IT Shared Service Center, thus they will be selected from those who are currently working for financial institutions that adopted the service.

### 4.Conclusion

The objective of this study is to find factors that have an influence on the focus in organization among IT departments in financial institutions which applied IT Shared Service Center. After the law on financial holding companies was enabled in 2000, financial institutions in South Korea were restructured to financial holding company system which is enabled to become large-sized and also to have sideline business. During this process, redundant IT departments from each financial subsidiary company were integrated and they started the application of IT Shared Service Center, which provides IT services to all the subsidiary companies of the financial holding company. The financial holding companies expected to have various positive effects with the application of IT Shared Service Center, such as reducing cost by utilizing the shared IT infrastructure and service, amplifying the synergy of integrated IT department and improving productivity, providing wide variety of professional IT service and reviewing the service quality, improving the management efficiency of IT service field by financial holding company, standardizing the request of developing work and process, etc. However, during the application of IT Shared Service Center, it is faced with difficulties because of IT employees who oppose the application of IT Shared Service Center. Besides, the companies that adopted the center did not achieve as much as expected particularly in terms of cost reduction, integrating IT professional service and improving the capabilities, not to mention the fundamental roles of IT Shared Service Center. This is caused by the negative recognition on the application of IT Shared Service Center after and during its application, which negatively influenced on the integration of organization. Because of the same reason, it cannot draw the employees’ voluntary focus on the organization that leads to both individual accomplishment and the performance of IT Shared Service Center.

Therefore, this study has two objectives: firstly, to determine whether the employees who experienced the change in organization after the application of IT Shared Service Center feel different with sentimental focus by distributive fairness, procedural justice, a threat to value in
position, and a threat to losing the job; secondly, to see if the effect on sentimental focus varies depending on the feeling of distributive fairness, procedural justice, a threat to value in position, and a threat of losing the job.

REFERENCE

BRANDING STRATEGY DEFINITIONS FOR HIGH TECHNOLOGY SERVICE FIRMS BY HYBRID MCDM METHODS

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ABSTRACT

The high technology services industry emerged in the past decades, and provides services including manufacture, purchase, design and logistic instead of traditional high technology manufacturing industry’s production, sales and marketing. At moment when the high technology service industry emerging, very few scholars tried to uncover the impacts of branding on a high technology service firm. Instead, most previous researches focused on general consumer goods industry. However, the empirical study results or theory constructions based on general consumer goods can’t really be applied on high technology industry in general and high technology service industry in special. Thus, this research aims to investigate the factors influencing branding strategies for high technology service firms and derive the most suitable branding strategies. Further, develop a multi criteria decision making (MCDM) framework for branding strategy definitions in high technology service firms. First of this research, use the Decision Making Trial and Evaluation Laboratory (DEMATEL) for configuring the decision problem structure. Then, the Analytical Network Process (ANP) as the tool for calculating weights of each criterion. Finally, the Grey Relational Analysis (GRA) method will be introduced for deriving the relationships between criteria and the branding strategy solution. Thus, the alternatives have been proposed for used the branding strategy of a high technology service firm. The empirical study on IC design service companies will be leveraged for verifying the usefulness of this proposed analytic framework on branding strategies. The result of this research will be standards and suggestions of the business strategy for high technology service industry.

Keywords: Branding Strategy, High Technology Services, Multiple Criteria Decision Making (MCDM), Decision Making Trial and Evaluation Laboratory (DEMATEL), Analytic Network Process (ANP)

1. Introduction

The high-technology service industry has emerged recently. Those high technology service firms provide manufacturing, purchasing, design and logistics services not only to emphasize on production, sales, marketing, etc. The concept of branding in the high-tech marketing management is gaining increasing attention since there is a general consensus that the brand is becoming daily important as high-tech services are becoming accessible to mass consumers [25;27;39]. Therefore, managers must realize that the branding strategy has become daily important for the high technology service firms. Further, most previous research on the branding strategy focuses on general consumer goods industry. There is notably little empirical research concerning high-tech brands. According to Zambuni [42] writes: “an area that is less well understood that fast-moving consumer goods or services branding”. The past research results or theory constructions based on consumer goods can’t really be applied on high technology industry in general and high technology service industry in special.

However, after IBM more high technology services firms use the technology to manufacturing their goods. Further, the firms will market their products by many branding strategy. By summarizing Kotler’s [17] viewpoint, branding strategy for a general (service) firm include line extension strategy, brand extension strategy, multi brands strategy and new brand strategy. The four strategic types correspond to Tauber [33] summarize viewpoint. Although some different literally, the meaning is no different. Such as introduce new brands in the existing product categories. Tauber called flanker brand strategy, and Kotler called multi-brand strategy. Further, the high technology service firms can find the best strategy to market their products. Thus, the purposes of the this research are twofold: (1) defining a multiple criteria decision making (MCDM) theories based high technology service firms branding strategy definition framework to resolve the above mentioned problem; (2) enhancing the competitiveness of high technology service firms in general and IC design service companies by using the branding strategy as the tool.

In this paper, the questionnaire included assessment criteria and branding strategy solution for the high technology services industry. The questionnaires were distributed to the director of Taiwan's IC design service companies. They will examine the criteria weight from the questionnaire.

This research is organized as follows. The related literature regarding to branding, branding strategy, high technology services and branding strategy of high technology firms will be reviewed in Section 2. The multiple criteria decision making (MCDM) method will be introduced in Section 3. The high technology services as a foundation for the empirical study to appear in Section 4. Discussion as well as managerial implications will be presented in Section 5. Finally, the whole article will be concluded in Section 6.

2. Literature Review

This Section demonstrates the basic concepts about branding strategy, high technology services, and the
branding strategy of the high technology firms. Through past literature review to investigate the basic concepts of those names or theory.

2.1 Branding

The brand and branding are defined as follows: “A brand as a name, term, sign, symbol or design, or a combination of them intended to identify the goods and services of one seller or groups of sellers and to differentiate them from those of competition” [18;24].

De Chernatony and McDonald [5] describe a brand as, an identifiable product augmented in such a way that the buyer or user perceives relevant unique added values which match their needs most closely. Furthermore, its success results from being able to sustain these added values in the face of competition. “A brand as a product, but one that adds other dimensions that differentiate it in some way from other products designed to satisfy the same need” [16]. “Branding means the use of a name, term, symbol, or design or a combination of these to identify a product”[21].

Firms are using branding as a strategy tool in today’s business environment with increasing regularity. Organizations develop brands as a way to attract and keep customers by promoting value, image, prestige, or lifestyle [12]. Although brands and branding are not new ideas, firms are applying them to more diverse settings where the role of branding is becoming increasingly important [40]. Business historians agree that branding itself is over 100 years old, with the majority of countries having trademark acts to establish the legality of a protected asset by 1890. It was from 1800 through 1925 that was known as the richest period of name-giving [13].

2.2. Branding Strategy

Deriving a branding strategy involves deciding the nature of new and existing brand identities to be applied to new and existing products [16;18]. We summarizing Kotler’s [17] viewpoint, branding strategy for a general (service) firm include (1) line extension strategy, (2) brand extension strategy, (3) multi brands strategy and (4) new brand strategy (For our summary, see Fig.1.). The branding strategies definition as follows:

(1) Line extension strategy occur when a company introduces additional items in a given category under the same brand name, such as new flavours, colours etc. (2) Brand extension strategy means to use a successful brand name to launch or modify products in a new category. (3) Multi brands strategy means a stable of brand names within the same product category. (4) New brands strategy means to introduce new brand names in a new product category.

The four strategic types correspond to Tauber [33] summarize viewpoint. Although some different literally, the meaning is no different. Such as introduce new brands in the existing product categories. Tauber called flanker brand strategy, and Kotler called multi-brand strategy (For our summary, see Fig.1.).

Source: Kotler [17]; Tauber [33]

Fig.1. Brand Strategy Matrix

2.3. High Technology Services

We compile the high technology services article. The literature review as follows. A revolution is at work in the high technology industry; the irresistible growth of business-to-business high tech services [38]. High tech services are the firms that offering a new range of sophisticated services to their corporate customers, quite different from the traditional hardware maintenance and repair services. Their business can be defined as offering value to their customers through services, based on innovative information technology (hardware and software) implemented by personnel who have required expertise and who rely heavily on methodology [38].

Successful innovation is crucial for firm survival in high-technology service industries. Effects of inter firm differences are investigated in the new service development phase of the innovation process [37]. Services involving the use of information and communication technology (ICT), contribute increasingly to the growth of the global economy. Revolutionary technological developments have created many opportunities for service innovation, while these new high-technology services potentially create significant value for providers as well as users [36]. As a consequence of the speed of technological developments and the related globalization of markets, most high-technology service providers currently experience hyper competition and exceptional turbulence in their marketplaces [1].

High technology services have some important distinguishing features [38]: (1) they are intangible; (2) their ownership is not transferred at the time of the purchasing; (3) customers are associated with them; (4) they are location independent but time dependent; (5) they are relatively homogeneous so they can be stored and quality controlled; (6)they cannot be easily demonstrated before purchasing. Increasingly short product life cycles are the result, implying an urgent need for continuous, fast, and effective innovation [19]. At the same time, the trend in the macro environment of firms has turned high-technology service is necessary.

2.4 Branding Strategy of High Technology Firms

Ingredient branding is a special form of alliance between two brands, based on their cooperation for designing and delivering the product, with particular emphasis on the possibility to recognize and identify the used components in the final product [26]. An ingredient branding strategy pulls demand from end users through the distribution channel back to the original equipment manufacturers (OEMs), who feel pressure to use the branded ingredient in the goods they make. Business-to-business
marketers will recognize this strategy as one designed to stimulate derived demand, whereby demand for the component, or ingredient, at the upstream level of the supply chain is derived from the end customers’ demand (at the downstream level of the supply chain) for the products in which the components are used. (Fig. 2. will show the supply chain)

![Ingredient Branding Supply Chain](image)

**Fig.2. Ingredient Branding Supply Chain**

Source: Mohr, et al. [22]

Ingredient branding seems to make the most sense when the supplier’s “ingredient” is integrally related to the performance capabilities of the end product in which it embedded. For example, Intel’s chip plays a key role in the performance capabilities of computers.

### 3. Methods

#### 3.1 The DEMATEL Method

The DEMATEL method was developed by the Battelle Geneva Institute (1) to analyze complex ‘world problems’ dealing mainly with interactive man-model techniques; and (2) to evaluate qualitative and factor-linked aspects of societal problems [11]. The applicability of the method is widespread, ranging from industrial planning and decision-making to urban planning and design, regional environmental assessment, analysis of world problems, and so forth. It has also been successfully applied in many situations, such as marketing strategies, control systems, safety problems, developing the competencies of global managers and group decision-making [4;14]. Furthermore, a hybrid model combining the two methods has been widely used in various fields, for example, e-learning evaluation [34] and innovation policy portfolios for Taiwan’s SIP Mall [14]. Therefore, in this paper we use DEMATEL not only to detect complex relationships and build a NRM of the criteria, but also to obtain the influence levels of each element over others; we then adopt these influence level values as the basis of the normalization supermatrix for determining ANP weights to obtain the relative importance. To apply the DEMATEL method smoothly, the authors refined the definitions based on above authors, and produced the essential definitions indicated below. The DEMATEL method is based upon graph theory, enabling us to plan and solve problems visually, so that we may divide multiple criteria into a relationship of cause and effect group, in order to better understand causal relationships. Directed graphs (also called digraphs) are more useful than directionless graphs, because digraphs will demonstrate the directed relationships of sub-systems. A digraph typically represents a communication network, or a domination relationship between individuals, etc. Suppose a system contains a set of elements, \(S = \{s_1, s_2, \ldots, s_n\}\), and particular pair-wise relationships are determined for modeling, with respect to a mathematical relationship, MR. Next, portray the relationship MR as a direct-relation matrix that is indexed equally in both dimensions by elements from the set \(S\). Then, extract the case for which the number 0 appears in the cell \((i, j)\), if the entry is a positive integral that has the meaning of: the ordered pair \((s_i, s_j)\) is in the relationship MR; it has the kind of relationship regarding that element such that \(s_i\) causes element \(s_j\). The digraph portrays a contextual relationship between the elements of the system, in which a numeral represents the strength of influence. The elements \(s_1, s_2, s_3, \ldots, s_n\) represent the factors that have relationships in Fig.3. The number between factors is influence or influenced degree. For example, an arrow from \(s_1\) to \(s_2\) represents the fact that \(s_1\) influences \(s_2\) and its influenced degree is two. The DEMATEL method can convert the relationship between the causes and effects of criteria into an intelligible structural model of the system [4].

![An Example of the Directed Graph](image)

**Fig.3. An Example of the Directed Graph**

**Definition 1:** The pair-wise comparison scale may be designated as eleven levels, where the scores 0,1,2,...,10 represent the range from ‘no influence’ to ‘very high influence’.

**Definition 2:** The initial direct relation/influence matrix \(A\) is an \(n \times n\) matrix obtained by pair-wise comparisons, in terms of influences and directions between the determinants, in which \(a_{ij}\) is denoted as the degree to which the \(i^{th}\) determinant affects the \(j^{th}\) INC.

\[
A = \begin{bmatrix}
a_{11} & a_{12} & \cdots & a_{1n} \\
a_{21} & a_{22} & \cdots & a_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
a_{n1} & a_{n2} & \cdots & a_{nn}
\end{bmatrix}
\]

**Definition 3:** The normalized direct relation/influence matrix \(N\) can be obtained through Equations (1) and (2), in which all principal diagonal elements are equal to zero.

\[
N = zA
\]

\[
z = \min \left\{ \frac{1}{\max \left( \sum_{j=i} a_{ij} \right)}, \frac{1}{\max \left( \sum_{i=j} a_{ij} \right)} \right\},
\]

\(i, j \in \{1,2,\ldots,n\}\)

In this case, \(N\) is called the normalized matrix. Since \(\lim_{l \to \infty} N^l = [0]\).

**Definition 4:** Then, the total relationship matrix \(T\) can be obtained using Equation (3), where \(I\) stands for the identity matrix. \(T = N + N^2 + \ldots + N^l = N(I - N)^{-1}\) (3)

where \(l \to \infty\) and \(T\) is a total influence-related matrix;
N is a direct influence matrix and $N = [x_{ij}]_{n \times n}$;

$$\lim_{l \to \infty} \left( N^2 + \cdots + N^l \right)$$

stands for a indirect influence matrix;

[Explanation]

$$T = N + N^2 + \cdots + N^l$$

$$= N(I + N + N^2 + \cdots + N^{l-1})(I - N)(I - N)^{-1}$$

$$= N(I - N)^{-1}, \text{ when } l \to \infty, \quad N^l = [0]_{n \times n} \quad \text{(3)}$$

where $0 \leq x_{ij} < 1$, $0 < \sum_{j=1}^{n} x_{ij} \leq 1$ and $0 < \sum_{i=1}^{n} x_{ij} \leq 1$, at least one row or column of summation is equal to 1, but not all, then $\lim_{l \to \infty} N^l = [0]_{n \times n}.

The $(i,j)$ element $t_{ij}$ of matrix $T$ denotes the direct and indirect influences of factor $i$ on factor $j$.

Definition 5: The row and column sums are separately denoted as $r$ and $c$ within the total-relation matrix $T$ through Equations (4), (5), and (6).

$$T = [t_{ij}], \quad i, j \in [1,2,\ldots,n] \quad \text{(4)}$$

$$r = [r_i]_{1 \times n} = \left( \sum_{j=1}^{n} t_{ij} \right)_{1 \times n} \quad \text{(5)}$$

$$c = [c_j]_{n \times 1} = \left( \sum_{i=1}^{n} t_{ij} \right)_{n \times 1} \quad \text{(6)}$$

where the $r$ and $c$ vectors denote the sums of the rows and columns, respectively.

Definition 6: Suppose $r_i$ denotes the row sum of the $i$th row of matrix $T$. Then, $r_i$ is the sum of the influences dispatching from factor $i$ to the other factors, both directly and indirectly. Suppose that $c_j$ denotes the column sum of the $j$th column of matrix $T$. Then, $c_j$ is the sum of the influences that factor $i$ is receiving from the other factors. Furthermore, when $i = j$ (i.e., the sum of the row sum and the column sum ($r_i + c_j$) represents the index representing the strength of the influence, both dispatching and receiving), ($r_i + c_j$) is the degree of the central role that factor $i$ plays in the problem. If ($r_i - c_j$) is positive, then factor $i$ primarily is dispatching influence upon the strength of other factors; and if ($r_i - c_j$) is negative, then factor $i$ primarily is receiving influence from other factors [14;20;32].

3.2 The Analytic Network Process Method

The ANP method, a multi criteria theory of measurement developed by Saaty [28], provides a general framework to deal with decisions without making assumptions about the independence of higher-level elements from lower level elements and about the independence of the elements within a level as in a hierarchy. Compared with traditional AHP (Analytic Hierarchy Process) [31] based applications which usually assume the independence between criteria, ANP, a new theory that extends AHP to deal with dependence in feedback and utilizes the supermatrix approach [28], is a more reasonable tool for dealing with complex MCDM problems in the real world. In this section, concepts of the ANP are summarized based on Saaty’s earlier works [28;29;31].

The ANP is a coupling of two parts. The first consists of a control hierarchy or network of criteria and subcriteria that control the interactions. The second is a network of influences among the elements and clusters. The network varies from criterion to criterion and a different supermatrix of limiting influence is computed for each control criterion. Finally, each of these supermatrices is weighted by the priority of its control criterion and the results are synthesized through addition for all the control criteria [30]. A control hierarchy is a hierarchy of criteria and subcriteria for which priorities are derived in the usual way with respect to the goal of the system being considered.

The criteria are used to compare the components of a system, and the subcriteria are used to compare the elements. The criteria with respect to which influence is presented in individual supermatrices are called control criteria. Because all such influences obtained from the limits of the several supermatrices will be combined in order to obtain a measure of the priority of overall influences, the control criteria should be grouped in a structure to be used to derive priorities for them. These priorities will be used to weight the corresponding individual supermatrix limits and add. Analysis of priorities in a system can be thought of in terms of a control hierarchy with dependence among its bottom-level alternatives arranged as a network as shown in Fig.4. Dependence can occur within the components and between them.

A control hierarchy at the top may be replaced by a control network with dependence among its components, which are collections of elements whose functions derive from the synergy of their interaction and hence has a higher-order function not found in any single element. The criteria in the control hierarchy that are used for comparing the components are usually the major parent criteria whose subcriteria are used to compare the elements need to be more general than those of the elements because of the greater complexity of the components.

Source: Saaty [28]

Fig.4. The Control Hierarchy

A network connects the components of a decision system. According to size, there will be a system that is made up of subsystems, with each subsystem made up of components, and each component made up of elements. The elements in each component interact or have an influence on some or all of the elements of another component with respect to a property governing the
interactions of the entire system, such as energy, capital, or political influence. Fig.5 demonstrates a typical network. Those components which no arrow enters are known as source components such as C1 and C2. Those from which no arrow leaves are known as sink component such as C5. Those components which arrows both enter and exit leave are known as transient components such as C3 and C4. In addition, C3 and C4 form a cycle of two components because they feed back and forth into each other. C2 and C4 have loops that connect them to themselves and are inner dependent. All other connections represent dependence between components which are thus known to be outer dependent.

![Diagram of network](Note: The diagram is not reproducible here. It shows a network with components C1, C2, C3, C4, and C5, with arrows indicating interdependencies.)

Source: Saaty [28]

Fig.5. Connections in a Network

A component of a decision network which was derived by the DEMATEL method in Section 3.1 will be denoted by \( C_h, h = 1, \ldots, m \), and assume that it has \( n_h \) elements (determinants), which we denote by \( e_{h1}, e_{h2}, \ldots, e_{hn} \). The influences of a given set of elements (determinants) in a component on any element in the decision system are represented by a ratio scale priority vector derived from paired comparisons of the comparative importance of one criterion and another criterion with respect to the interests or preferences of the decision makers. This relative importance value can be determined using a scale of 1–9 to represent equal importance to extreme importance [28]. The influence of elements (determinants) in the network on other elements (determinants) in that network can be represented in the following supermatrix \( W \).

A typical entry \( W_{ij} \) in the supermatrix, is called a block of the supermatrix in the following form where each column of \( W_{ij} \) is a principal eigenvector of the influence of the elements (determinants) in the \( j^{th} \) component of the network on an element (determinants) in the \( i^{th} \) component. Some of its entries may be zero corresponding to those elements (determinants) that have no influence.

\[
\begin{bmatrix}
W_{i1} & W_{i2} & \cdots & W_{in} \\
W_{j1} & W_{j2} & \cdots & W_{jn} \\
\vdots & \vdots & \ddots & \vdots \\
W_{n1} & W_{n2} & \cdots & W_{nn}
\end{bmatrix}
\]

After forming the supermatrix, the weighted supermatrix is derived by transforming all columns sum to unity exactly. This step is very much similar to the concept of the Markov chain in terms of ensuring that the sum of these probabilities of all states equals 1. Next, the weighted supermatrix is raised to limiting powers, such as Equation (7) to get the global priority vector or called weights [15].

\[
limit_{k \to \infty} W^k = \lim_{k \to \infty} \left( \sum_{j=1}^{n} W_{ij} \right)
\]

In addition, if the supermatrix has the effect of cyclicity, the limiting supermatrix is not the only one. There are two or more limiting supermatrices in this situation, and the Cesaro sum would need to be calculated to get the priority. The Cesaro sum is formulated as follows.

\[
w = \lim_{y \to \infty} \left( \frac{1}{y} \sum_{j=1}^{n} W_{ij} \right)
\]

To calculate the average effect of the limiting supermatrix (i.e. the average priority weights can be shown by the vector \( w \) ) where \( W_j \) denotes the \( j^{th} \) limiting supermatrix. Otherwise, the supermatrix would be raised to large powers to get the priority weights [15]. The weights of the \( k^{th} \) determinants derived by using the above ANP processes, namely \( \alpha_k, \ k \in \{1, 2, \ldots, n\} \), will be used as weights for aggregating the performance score versus each alternative.

### 3.3 Grey Relational Analysis

Since Deng [6] proposed Grey theory, related models have been developed and applied to MCDM problems. Similar to fuzzy set theory, Grey theory is a feasible mathematical means that can be used to deal with systems analysis characterized by inadequate information. Fields covered by the Grey theory include systems analysis, data processing, modeling, prediction, decision-making, and control engineering [7;9;10;35]. In this section, we briefly...
review some relevant definitions and the calculation process for the Grey Relation Model. This research modified the definitions by Chiou and Tzeng [3] and produced the definitions indicated below. GRA is used to determine the relationship between two sequences of stochastic data in a Grey system. The procedure bears some similarity to pattern recognition technology. One sequence of data is called the ‘reference pattern’ or ‘reference sequence,’ and the correlation between the other sequence and the reference sequence is to be identified [8;23;41;35]. The relationship scale also may be designated into eleven levels, where the scores 0,1,2,…,10 represent the range from ‘no relationship’ to ‘very high relationship’ between the specified evaluation criteria and the fuel cell technologies. The initial relationship matrix \( G \) is a \( m \times n \) matrix, where there are \( m (k = 1,2,...,m) \) fuel cell technologies and \( n \) criteria (\( j = 1,2,...,n \)), obtained by surveying the relationships, where \( g_{ij} \) is denoted as the relationship between the \( j \)th criterion and the \( k \)th technology.

\[
G = \begin{bmatrix}
g_{11} & \cdots & g_{1j} & \cdots & g_{1n} \\
g_{21} & \cdots & g_{2j} & \cdots & g_{2n} \\
\vdots & \ddots & \vdots & \ddots & \vdots \\
g_{m1} & \cdots & g_{mj} & \cdots & g_{mn}
\end{bmatrix}
\]

The normalized relationship matrix \( G \) can be obtained through Equations (9) and (10).

\[
x_k(j) = \frac{g_{kj}}{\text{aspiration-value } x_k(j)}
\]

(9)

\[
X = \begin{bmatrix}
x_1(j) & \cdots & x_j(j) & \cdots & x_n(j) \\
x_1(1) & \cdots & x_j(1) & \cdots & x_n(1) \\
\vdots & \ddots & \vdots & \ddots & \vdots \\
x_1(n) & \cdots & x_j(n) & \cdots & x_n(n)
\end{bmatrix}
\]

(10)

In this case, let \( x_0 \) be the aspiration-value vector with \( n \) criteria: \( x_0 = (x_0(1),...,x_0(j),...,x_0(n)) = (10,...,10,...,10) \) and the matrix containing the normalized mapping information of each strategy (fuel cell technology) to the innovation competence (criteria), be one of the \( m \) strategic patterns with \( n \) criteria to be compared with the aspiration vector \( x_0 \) where \( x_i \) is written as: when \( x_i = x_i(j) \), \( j = 1,2,...,n \) in Eqs (9) and (10), then \( x_i = (x_i(1),...,x_i(j),...,x_i(n)) \), \( k = 1,2,...,m \). How much grade of strategy \( x_i \) close to aspiration level \( x_0 \) in cell technology. Let \( X \) be a normalized strategic performance set of grey relations, \( x_0 \in X \) the aspiration level for referential sequence, and \( x_i \in X \) the \( k \)th strategy for comparative sequence; with \( x_i(j) \) and \( x_j(j) \) representing the numerals at criterion \( j \) for \( x_0 \) and \( x_i \), respectively. If \( \gamma(x_i(j),x_j(j)) \) and \( \gamma(x_i,j) \) are real numbers, and satisfy the grey axioms being defined in Deng [8], then call \( \gamma(x_i(j),x_j(j)) \) the grey relation coefficient, and the grade of the grey relation \( \gamma(x_0,x_i) \) is the average value of \( \gamma(x_0(j),x_i(j)) \). Deng also proposed a mathematical equation for the grey relation coefficient, as follows:

\[
\gamma(x_0(j),x_i(j)) = \min \begin{bmatrix} \gamma(x_0(j),x_i(j)) \end{bmatrix} + \zeta \max \begin{bmatrix} \gamma(x_0(j),x_i(j)) \end{bmatrix}
\]

(11)

where \( \zeta \) is the coefficient (\( \zeta \in [0,1] \)). Generally, \( \zeta = 0.5 \).

Based on Deng [8], if the grey relation coefficient in \( x_i(j) \) corresponding to \( x_0(j) \) is \( \gamma(x_i(j),x_0(j)) \), then the grey relation grade in \( x_i \) corresponding to \( x_0 \), \( \gamma(x_0,x_i) \), must satisfy the following four axioms.

1. Norm Interval: \( \gamma(x_0(j),x_i(j)) \leq 1 \), \( \forall j \); \( \gamma(x_0,j) = 1 \iff x_0 = x_i \);

(12)

where \( \forall j \in \phi \) is an empty set.

2. Duality Symmetric: \( x_j \in X \Rightarrow \gamma(y,x) = \gamma(x,y) \iff x = \{x,y\} \).

3. Wholeness:

\[
\gamma(x_0,x_j) = \gamma(x_0,j) \leq 1,
\]

\( m > 2 \).

4. Approachability: \( \gamma(x_0(j),x_i(j)) \) decreases when \( [x_0(j) - x_i(j)] \) increases.

If \( \gamma(x_0,j) \) satisfies the four grey relation axioms, then \( \gamma \) is called the Grey Relational Map. If \( \Gamma \) is the entirety of the grey relational map, \( \gamma \in \Gamma \) satisfies the four axioms of the grey relation, and \( X \) is the factor set of the grey relation, then \( (X, \Gamma) \) will be called the grey relational space, while \( \gamma \) is the specific map for \( X \). Let \( (X, \Gamma) \) be the grey relational space, and if \( \gamma(x_0,j) \), \( \gamma(x_0,x_j) \), \( \gamma(x_0,x_j) \), \( \gamma(x_0,x_j) \), \( \gamma(x_0,x_j) \), \( \gamma(x_0,x_j) \), then we have the grey relational order: \( x_0 > x_1 > x_2 > \cdots > x_n \). When the grey relational coefficient is conducted with respect to various fuel cell technologies, we then can derive the grade of the grey relation \( \gamma(x_0,x_i) \) between the reference alternative \( \gamma(x_0,x_i) = \sum w_j \gamma(x_0(j),x_i(j)) \) where \( w_j \) is the number of criteria (innovation competences), \( w_j \) expresses the weight of the \( j \)th criterion, by ANP and \( \gamma(x_0,x_i) \) represents the grade of grey relation in \( x_i \) (shown as \( k \)th manufacturing or logistics strategy) correspondence to \( x_0 \) (aspiration level). In this study, we make the order of the strategies following the grade of grey relation.

4. Analyzing the Factors Influencing Branding Strategies

This Section shows the IC design service industry introduction first. Then, thirteen criteria belong to four aspect, brand equity, cost, industrial structure and environment, are summarized from literature and experts’ viewpoint. Finally, an Empirical Study on High Technology Service industries’ branding strategies will be introduced. The detailed process for this empirical study will be introduced as following.

4.1 The IC Design Service Industry Introduction

The IC design service industry is a high technology knowledge industry. Throughout the value chain system,
the industry stresses the importance of vertical disintegration. The IC design service is a new business model emerging as a vertical disintegration product in the IC industry. We codify the IC design service industry development from the 1970s to the 2000s. In the 1970s, including IC design and an integrated device manufacturer (IDM) fabrication assembly test, the IC industry combines multi-processes into one complete system. Then, IC-designs and IDM separated from one complete set system to develop two subsystems of IC design and IDM fabrication in the 1980s. Further, including IC design and IDM fabrication and assembly continue developed. The IC industry after the 1980s modified processing to include the system, IC design, IDM fabrication, IC foundry, IC assembly and IC test on the subsystem. After 2000, the IC design subsystem expands from one to three parts, including system in package (SIP), design system and IC design. Thus, the IC design service industry has become an important process of the IC design system [2]. Meanwhile, the IC design service industry is multi-dimensional and highly competitive industry. When the company decided to develop branding strategies, the MCDM model can helps to selection the suitably solutions in the IC design service industry.

### 4.2 Criteria and Alternatives Derivations

Ten experts in IC design service companies were invited to evaluate each of the first four criteria of the function aspect. (For our summary, see Table 1)

Table 1 Aspect and Criteria for Branding Strategies Selection

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brand Equity (A1)</td>
<td>(c1) Brand Loyalty (c2) Brand Awareness (c3) Brand Association (c4) Perceived Quality (c5) Price</td>
</tr>
<tr>
<td>Cost (A2)</td>
<td>(c6) Human Capital (c7) R&amp;D Expenditure</td>
</tr>
</tbody>
</table>

Source: This Research

### 4.3 An Empirical Study on High Technology Service industries’ branding strategies

First, the structure of branding strategies selection problem was established by using the DEMATEL. Then, using the ANP method derived the weight versus each criterion. Finally, the Grey Relational Analysis (GRA) method will be introduced for deriving the relationships between criteria and the branding strategy solution. Since the inter-relationship for individual dimensions between criteria which are summarized through the literature review and professional experts based brainstorming process. All of the criteria of the aspects decision problem structure will be deducted by using the DEMATEL method which was introduced in Section 3.1.

At first, the direct relation matrix $A_1$ is individual introduced as shown in Fig.6-1 according to the experts’ opinions on pair-wise comparisons in terms of influence and direction between evaluation criteria. After that, the normalized direct relation matrix $N_1$ is shown in Fig.6-2 and the normalized direct relation matrix $N_1$ is normalized based on Equation (1). Finally, the total relationship matrix $T_1$ shown in Fig.6-3 and the total relationship matrix $T_1$ is deducted based on Equation (3). At the same time, in accordance with the above steps on other aspects and criteria by using the DEMATEL method. Following, the detailed process by using the DEMATEL method will be introduced.

$A_1 = \begin{bmatrix}
0.000 & 3.316 & 3.409 & 4.136 \\
3.977 & 0.000 & 3.977 & 3.705 \\
3.614 & 3.568 & 0.000 & 2.932 \\
4.273 & 3.909 & 4.091 & 0.000 
\end{bmatrix}$

Fig.6-1 The Direct Relation Matrix $A_1$

$N_1 = \begin{bmatrix}
0.000 & 0.256 & 0.278 & 0.337 \\
0.324 & 0.000 & 0.324 & 0.302 \\
0.294 & 0.291 & 0.000 & 0.239 \\
0.348 & 0.319 & 0.333 & 0.000 
\end{bmatrix}$

Fig.6-2 The Normalized Direct Relation Matrix $N_1$

$T_1 = \begin{bmatrix}
2.370 & 2.378 & 2.526 & 2.457 \\
2.768 & 2.315 & 2.703 & 2.579 \\
2.486 & 2.297 & 2.200 & 2.295 \\
2.883 & 2.649 & 2.807 & 2.442 
\end{bmatrix}$

Fig.6-3 The Total Relationship Matrix $T_1$

Fig.6. Decision Problem Structuring for Cost

$$A_2 = \begin{bmatrix}
0.000 & 3.705 & 3.886 \\
4.000 & 0.000 & 3.818 \\
4.545 & 3.545 & 0.000 
\end{bmatrix}$$

Fig.7-1 The Direct Relation Matrix $A_2$

$$N_2 = \begin{bmatrix}
0.000 & 0.434 & 0.455 \\
0.468 & 0.000 & 0.447 \\
0.532 & 0.415 & 0.000 
\end{bmatrix}$$

Fig.7-2 The Normalized Direct Relation Matrix $N_2$

$$T_2 = \begin{bmatrix}
3.565 & 3.487 & 3.634 \\
3.955 & 3.248 & 3.697 \\
4.069 & 3.617 & 3.467 
\end{bmatrix}$$

Fig.7-3 The Total Relationship Matrix $T_2$

Fig.7. Decision Problem Structuring for Brand Equity

$$A_3 = \begin{bmatrix}
0.000 & 3.909 & 3.818 \\
3.273 & 0.000 & 3.545 \\
4.545 & 3.545 & 0.000 
\end{bmatrix}$$

Fig.8-1 The Direct Relation Matrix $A_3$
Based on the decision problem structure being derived by the DEMATEL, the ANP method can be applied for calculating the weight versus each criterion. The limit super matrix \( W \) is calculated and shown in all of Figure 11. Then, the performance values of the evaluation criteria being rated against each criterion and aggregated are presented in all of Table 2.

### Table 2 The Weight of the Criteria for Branding Strategies Selection

<table>
<thead>
<tr>
<th>Criteria</th>
<th>( \epsilon_1 )</th>
<th>( \epsilon_2 )</th>
<th>( \epsilon_3 )</th>
<th>( \epsilon_4 )</th>
<th>( \epsilon_5 )</th>
<th>( \epsilon_6 )</th>
<th>( \epsilon_7 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>0.067</td>
<td>0.068</td>
<td>0.072</td>
<td>0.064</td>
<td>0.07</td>
<td>0.098</td>
<td>0.084</td>
</tr>
</tbody>
</table>

Source: This Study

After constructing the structure of the decision problem, weights versus each criterion was derived by using the ANP (refer Table 2). The GRA is applied to derive the relationships between criteria and Branding Strategies then. The initial relationship matrix for deriving branding strategy, \( G \), is a \( 5 \times 13 \) matrix, where there are five branding strategies and thirteen determinants for high technology industry, obtained by surveying the relationships. The normalized relationship matrix \( X \) can be obtained through Equations (9) and (10). The grey relation coefficients can be calculated by using Equation (11). By setting the distinguished coefficient \( \zeta \) as 0.5, the grey relation coefficients were derived. Then the grades of grey relation \( \gamma(x_n, x) \) were derived. We established the result that Type 1 \( \rightarrow \) Type4 \( \rightarrow \) Type2 \( \rightarrow \) Type5 \( \rightarrow \) Type 3. Finally, the Grey grades versus each branding strategy were derived and shown in Table 3.

### Table 3 The grades of Grey relation with respect to branding strategy \( (\zeta = 0.5) \)

<table>
<thead>
<tr>
<th>Type</th>
<th>Branding Strategy</th>
<th>Grey Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>New brands</td>
<td>0.798</td>
</tr>
<tr>
<td>2</td>
<td>Multi brands</td>
<td>0.616</td>
</tr>
<tr>
<td>3</td>
<td>Brand extension</td>
<td>0.589</td>
</tr>
<tr>
<td>4</td>
<td>Line extension</td>
<td>0.700</td>
</tr>
<tr>
<td>5</td>
<td>Ingredient brand</td>
<td>0.597</td>
</tr>
</tbody>
</table>

### 5. Discussion

The new brands strategy is ranked as the best and suitable branding strategy solution while the line extension is ranked as the second better solution in this study.

Based on the result, it is apparent that since the high
technology services industry development, the high technology service firms not only need get profit, they should to develop branding strategies to enhance competitive power and extend the enterprise value. In addition, most previous research of the branding strategies only discuss with general consumer goods industry. This research demonstrates how comparisons could be made while selecting the model, which gives a clear direction for high tech managers. It can apply to drawing suggestions of high technology service branding strategies. In comparison with earlier researches on branding strategies, this research proposed a feasible quantitative analytic framework which link branding strategies theories to practical problems.

6. Conclusion

This research develops a scientific framework for the branding strategy of the high technology service industry in MCDM environment. Those methods can be applied to other industry area to define the branding strategies. It also can provide superior insights to help high technology services firms avoid the wrong decision when the firms will development or extend their brand. Due to the high technology service industry is a multi-dimensional and highly competitive industry. This research found that both time to market and human capital are the most important criteria, while industrial division, research & development, industry life cycle also are important in developing or extending the high technology services firms’ branding strategies. Thus, the manager should increase abilities to improve these decision problems.

Further, this research suggests that the new brands strategy is the best and suitable branding strategy for high technology services firms. Those high technology services firms can try to use the new brands strategy enhance competitive power and increase the branding value while gain higher profits. Finally, the analytical framework presented in this research can be applied to other industries for branding strategy.

REFERENCES


ANALYTIC SOLUTION FOR THE NUCLEOLUS OF A THREE-PLAYER COOPERATIVE GAME

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Abstract

The nucleolus solution for cooperative games in characteristic function form is usually computed numerically by solving a sequence of linear programming (LP) problems, or by solving a single, but very large-scale, LP problem. This paper proposes an algebraic method to compute the nucleolus solution analytically (i.e., in closed-form) for a three-player cooperative game in characteristic function form. We first consider cooperative games with empty core and derive a formula to compute the nucleolus solution. Next, we examine cooperative games with non-empty core and calculate the nucleolus solution analytically for five possible cases arising from the relationship among different coalition values.

Key words: Three-player cooperative game in characteristic function form, nucleolus, linear programming.

EXTENDED ABSTRACT

Cooperative game theory studies situations involving multiple players who can cooperate and take joint actions in a coalition to increase their “wealth.” The important problem of allocating the newly accrued wealth among the cooperating players in a fair manner has occupied game theorists since the 1940s. More than a dozen alternate solution concepts have been proposed to determine the allocation but only a few of these concepts have received the most attention. Von Neumann and Morgenstern [21] who were the originators of multiperson cooperative games proposed the first solution concept for such games known as the stable set. However, due to the theoretical and practical difficulties associated with it, the stable set concept fell out of favour. In 1953, Gillies [6] introduced the concept of core as the set of all undominated payoffs (i.e., imputations) to the players satisfying rationality properties. Even though the core has been found useful in studying economic markets, it does not provide a unique solution to the allocation problem. Also in 1953, Shapley [18] wrote three axioms which would capture the idea of a fair allocation of payoffs and developed a simple, analytic, expression to calculate the payoffs. Shapley value can be computed easily by using a formula regardless of whether or not the core is empty. However, when the core is nonempty, Shapley value may not be in the core and under some conditions the allocation scheme in terms of Shapley value may result in an unstable grand coalition.

An alternative solution concept known as the nucleolus was introduced by Schmeidler [17] in 1969 who proposed an allocation scheme that minimizes the “unhappiness” of the most unhappy player. Schmeidler [17] defines “unhappiness” (or, “excess”) of a coalition as the difference between what the members of the coalition could get by themselves and what they are actually getting if they accept the allocations suggested by a solution. It was shown by Schmeidler [17] that if the core for a cooperative game is non-empty, then the nucleolus is always located inside the core and thus assures stability of the grand coalition. Unfortunately, unlike the Shapley value, there exists no closed-form formula for the nucleolus solution which has to be computed numerically in an iterative manner by solving a series of linear programming (LP) problems, or by solving a very large-scale LP problem (see, for example, Owen [14] and Wang [22] for textbook descriptions of these methods). The objective of this paper is to present analytic expressions to calculate the nucleolus solution directly without the need for iterative calculations that involve the solution of linear programs.

The nucleolus solution is an important concept in cooperative game theory even though it is not easy to calculate. As Maschler et al. [11, p. 336] pointed out, the nucleolus satisfies some desirable properties—e.g., it always exists uniquely in the core if the core is non-empty, and is therefore considered an important fair division scheme. As a consequence, some researchers have used this concept to analyze business and management problems; but, due to the complexity of the calculations, the nucleolus has not been extensively used to solve allocation-related problems. As an early application of the nucleolus concept, Barton [1] suggested the nucleolus solution as the mechanism to allocate joint costs among entities who share a common resource. Barton showed that using the nucleolus for this allocation problem can reduce the possibility that one or more entities may wish to withdraw from the resource-sharing arrangement. For other publications concerning the applications of the nucleolus, see, e.g., Du et al. [4], Gow and Thomas [7], and Leng and Parlar [10].

An n-player game in characteristic-function form (as originally formulated by von Neumann and Morgenstern [21, Ch. VI]) is defined by the set N = {1, 2, ..., n} and a function v(·) which, for any subset (i.e., coalition) S ⊆ N gives a number v(S) called the value of S (see, also, Straffin [20, Ch. 23]). The characteristic value of the coalition S, denoted by v(S), is the payoff that all players in the coalition S can jointly obtain. For a characteristic function game (N, v), let x_i represent an imputation (i.e., a payoff) for player i = 1, 2, ..., n. The nucleolus solution is defined as an n-tuple imputation x = (x_1, x_2, ..., x_n) such that the excess (“unhappiness”) e_S(x) = v(S) − ∑_i∈S x_i of
any possible coalition \( S \) cannot be lowered without increasing any other greater excess; see, Schmeidler [17]. With this definition, we find that the nucleolus of a cooperative game is a solution concept that makes the largest unhappiness of the coalitions as small as possible, or, equivalently, minimizes the worst inequity. In the sequential LP method that is based on lexicographic ordering (Maschler et al. [11]), to find the nucleolus solution we first reduce the largest excess \( \max \{ e_S(x), \text{ for all } S \subseteq N \} \) as much as possible, then decrease the second largest excess as much as possible, and continue this process until the \( n \)-tuple imputation \( x \) is determined.

Existing solution methods for the nucleolus either solve a series of linear programming (LP) problems or a single, but very large LP; see, Table 1. The description of the methods to find the nucleolus as summarized in Table 1 shows that most LP-based methods are iterative in nature and when they are not iterative, the resulting LP can be quite large (as in Kohlberg [9] and Owen [13]).

1. If \( v(123) \geq 3v(ij) \), for \( i, j = 1, 2, 3 \) and \( i \neq j \), then \( y_1 = y_2 = y_3 = \frac{1}{3}v(123) \).
2. If \( v(123) \geq v(ij) + 2v(ik), v(123) \geq v(ij) + 2v(jk) \) and \( v(123) \leq 3v(ij) \), for \( i, j, k = 1, 2, 3 \) and \( i \neq j \neq k \), then \( y_i = \frac{1}{4}(v(123) + v(ij)) \) and \( y_k = \frac{1}{2}(v(123) - v(ij)) \).
3. If \( v(123) \leq v(ij) + 2v(ik), v(123) \geq v(ij) + 2v(jk) \) and \( v(ij) \geq v(ik) \), for \( i, j, k = 1, 2, 3 \) and \( i \neq j \neq k \), then \( y_i = \frac{1}{2}(v(ij) + v(ik)), y_j = \frac{1}{2}(v(123) - v(ik)), \) and \( y_k = \frac{1}{2}(v(123) - v(ij)) \).

In this paper we focus on three-player cooperative games in characteristic-function form, and present an algebraic method that determines the nucleolus analytically (i.e., using closed-form expressions) without the need for iterative algorithms. We first present our analysis for the relatively simpler case of a cooperative game with empty core. If the core of a three-player cooperative game in characteristic function form is empty, then the nucleolus solution \( y=(y_1, y_2, y_3) \) is computed as,

\[
y_i = \frac{v(123) + v(ik) + 2v(jk)}{3},
\]

for \( i, j, k = 1, 2, 3 \) and \( i \neq j \neq k \)

We next derive the formulas that are used to compute the nucleolus solution for a three-player cooperative game with a non-empty core. For a three-player, nonempty-core cooperative game in characteristic function form, the nucleolus solution \( y=(y_1, y_2, y_3) \) can be computed as follows:

\[
y_i = \frac{1}{2}(v(ij) + v(ik)), y_j = \frac{1}{2}(v(123) - v(ik)), \) and \( y_k = \frac{1}{2}(v(123) - v(ij)) \).

<table>
<thead>
<tr>
<th>Year</th>
<th>Author(s)</th>
<th>Brief Description of Major Algorithms in the LP Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1972</td>
<td>Kohlberg [9]</td>
<td>When the set of payoff vectors is a polytope, the nucleolus can be obtained as the solution of a single LP problem with ( n ) variables and ( (2^n)^n ) constraints.</td>
</tr>
<tr>
<td>1974</td>
<td>Owen [13]</td>
<td>When the set of payoff vectors is a polytope, the nucleolus can be obtained as the solution of a single LP problem with ( 2^{n+1} + n ) variables and ( 4^n + 1 ) constraints.</td>
</tr>
<tr>
<td>1979</td>
<td>Maschler, Peleg and Shapley [11]</td>
<td>The nucleolus was characterized as the lexicographic center of a cooperative game, and it can be found by solving a series of ( O(4^n) ) minimization LP problems with constraint coefficients of either (-1, 0, ) or (1).</td>
</tr>
<tr>
<td>1981</td>
<td>Behringer [2]</td>
<td>Simplex-based algorithm developed for general lexicographically extended linear maxmin problems to find the nucleolus by solving a sequence of ( O(2^n) ) LP problems.</td>
</tr>
<tr>
<td>1981</td>
<td>Dragan [3]</td>
<td>Using the concept of coalition array, linear programs with only ( O(n) ) rows and ( O(2^n) ) columns are used to find the nucleolus solution.</td>
</tr>
<tr>
<td>1991</td>
<td>Sankaran [16]</td>
<td>Algorithm to find the nucleolus solution by solving a sequence of ( O(2^n) ) LP problems. However, this method needs more constraints than in Behringer [2].</td>
</tr>
<tr>
<td>1994</td>
<td>Solymosi and Raghavan [19]</td>
<td>Algorithm to determine the nucleolus of an assignment game. In an ( (m, n) )-person assignment game, the nucleolus is found in at most ( m(n + 3)/2 ) steps, each one requiring at most ( O(mn) ) elementary operations.</td>
</tr>
<tr>
<td>1996</td>
<td>Potters, Reijnierse and Ansing [15]</td>
<td>The nucleolus solution can be found by solving at most ( n - 1 ) linear programs with at most ( 2n-1 ) rows and ( 2n+n-1 ) columns.</td>
</tr>
<tr>
<td>1997</td>
<td>Fromen [5]</td>
<td>By utilizing Behringer’s algorithm [2], the number of LP problems to find the nucleolus is reduced to ( O(n) ).</td>
</tr>
</tbody>
</table>

Table 1: A brief review of important algorithms to compute the nucleolus using the LP method.

4. If \( v(123) + v(ij) \geq 2[v(ik) + v(jk)], v(123) \leq v(ij) + 2v(ik) \) and \( v(123) \leq v(ij) + 2v(jk) \) for \( i, j, k = 1, 2, 3 \) and \( i \neq j \neq k \), then \( y_i = \frac{1}{4}(v(123) + v(ij) + 2[v(ik) - v(jk)]), y_j = \frac{1}{4}(v(123) + v(ij) + 2[v(jk) - v(ik)]), y_k = \frac{1}{2}(v(123) - v(ij)). \)
5. If \( v(123) + v(ij) \leq 2[v(ik) + v(jk)], \) for \( i, j, k = 1,2,3 \) and \( i \neq j \neq k, \) then \( y_i = \frac{1}{3}[v(123) + v(ij) + v(ik) - 2v(jk)], y_j = \frac{1}{3}[v(123) + v(ij) + v(jk) - 2v(ik)], y_k = \frac{1}{3}[v(123) + v(ik) + v(jk) - 2v(ij)]. \)

In this paper, we propose an algebraic method that gives the nucleolus analytically, to simplify the computations in calculating the nucleolus. This paper focuses on a three-player cooperative game. Only a single formula is needed for computing the nucleolus solution when the core of a three-player game is empty; and, for the nonempty-core game, we need some formulas each used under three specific conditions.

References


IMPROVING CUSTOMER SATISFACTION IN MULTISTAGE SERVICE DELIVERY SYSTEMS: APPLYING A MODELING FRAMEWORK TO MAKE RESOURCE ALLOCATION DECISIONS IN A HOTEL SETTING

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1. INTRODUCTION

A large body of literature exists on drivers and antecedents of non financial measures of performance, such as for example customer satisfaction (CS). Most of these studies have focused on exploring and establishing the importance of CS relative to other measures of interest such as, for example, market share (Harrington, 1980), repurchase intentions (Cronin and Taylor, 1992) and profitability (Jacobson and Aaker, 1987), or shedding light on its drivers and on issues of measurement. There is a dearth, however, of literature that focuses on the application of modeling frameworks that can guide the service manager towards making operational decisions regarding the improvement of CS, while taking into account other issues such as for example the different costs involved.

In this paper, we demonstrate the applicability of one such modeling framework that examines how and where resources should be allocated in a multistage service delivery system, in order to improve overall CS. Soteriou and Hadjinicola (1999) have developed a modeling framework (SH) that focuses on issues of service quality and considers how different factors interact to provide optimal allocation schemes. In this paper, we show a different approach to the SH framework which considers the construct of CS, and as a result makes the use of the SH framework much simpler. We provide an empirical investigation of the SH framework in the multistage setting of a hotel and we discuss managerial implications.

2. BACKGROUND

2.1 Customer Satisfaction (CS)

Most of the work on customer satisfaction in the marketing literature builds on the seminal work of Oliver (1994). Many different approaches on its conceptualization have been presented with the most popular of these, being perhaps the expectancy-disconfirmation theory, which asserts that customer satisfaction is a function of the disconfirmation which results from the difference between customers’ expectations of service and actual perceived service performance (Oliver, 1994). The relationship of CS with other concepts such as satisfaction, customer loyalty, and profitability, has also been extensively studied in the service management and marketing literatures (see, for example, among others Anderson et al., 1994; Soteriou and Zenios, 1999). This relationship has been a central part of many performance frameworks in the above literatures, such as for example, the service profit chain. A common underlying argument is that customer satisfaction influences customer loyalty, which in turn, affects long term profitability.

2.2 The SH resource allocation modeling framework

The SH framework builds on the work of Rust et al. (1994), which considers investment on improving service quality as a resource allocation decision. The SH framework considers a multistage service system, where customers visit a number of different stages before departure, and assumes that customer perceptions change as customers go through the system. The following model captures the interplay between several important factors on the optimal resource allocation aimed to improve overall service quality perceptions in a multistage service system, given some fixed budget $D$. For each stage, these factors include the current level of service quality perceptions $P_i$, a parameter $h_i$ reflecting the cost of improving service quality, and finally, the importance $w_i$ placed by customers on this stage.

$$\text{(M1)} \quad \min_{\delta_i, t=1,2,...,n} \sum_{i=1}^{n} \delta_i (M - P_i) \omega_i$$

$$\text{s.t.} \quad D = \sum_{i=1}^{n} h_i [(1/\delta_i) - 1]$$

where $1 - \delta_i$ reflects the improvement at each stage $i$ and $M$ the maximum level of the scale used to measure quality perceptions. For further discussion, the solution of the model, and for sensitivity analysis see Soteriou and Hadjinicola (1999). The benefits of the SH model lie in providing a unique optimal solution to the service manager who must consider trade-offs of the aforementioned factors, while remaining within some pre-specified budget.

3. DEMONSTRATING THE APPLICABILITY OF THE FRAMEWORK

In order to demonstrate the applicability of this framework in a multistage service setting we chose a hotel setting in Europe. Management was eager to apply the framework as part of a broader total quality management initiative undertaken at the hotel. For the purposes of this study, we focused on the different stages that a customer visits before departure. After checking out, customers provide feedback regarding their experience at the hotel, which can be used as an input to the model.

Capturing customers perceptions regarding their experience at each stage is a difficult task. Soteriou and Hadjinicola (1999) discuss some of the challenges involved in directly applying the SH framework, the most important of which includes the collection of service...
quality related perceived data. They discuss how service quality information for each stage can be extremely difficult to obtain. If one used, for example, a SERVQUAL-based instrument in a 5-stage setting, the resulting number of questionnaire items would exceed 200, making it difficult to use.

In this paper we use a cognitively-based satisfaction instrument based on an axiological value realm model suggested by Hartman (1967), as discussed by Danaher and Mattsson (1994). The instrument can be used to collect quality factor data along three generic value dimensions: emotional (E), practical (P), and logical (L). These three dimensions were shown to explain a large part of the variation of customer’s satisfaction at each stage. The simplicity of their instrument makes it particularly attractive for the case of multistage service systems with a large number of stages.

Upon check out, customers were requested to complete a questionnaire that was found on-line at a check out booth next to the reception area. Customers dragged and dropped the mouse, using a novel computer application on a continuous scale (1–100) depending on their levels of satisfaction for each of Hartman’s dimensions for each stage and for their overall satisfaction. The stages included check in and check out, room, restaurant and breakfast. A total of 556 responses, during a week period, from randomly selected hotel guests were used for the study.

Other inputs to the model include the cost for improving each stage and the importance the customers place on each stage. These are often not easy to determine. The parameter $h_i$ in (2) reflects the investment required to half the perceived loss $M-P_i$, at each stage. Properly specifying this parameter is not an easy task. In this paper we discuss how a framework proposed by Chase and Stewart (1994) known as 3Ts, consisting of three dimensions ---task, treatment and tangibles-- can guide the identification of relevant cost drivers at each stage. We further discuss how cost data were properly discounted for, to reflect yearly investments, so that they can provide meaningful input to the modeling framework.

The following table presents mean values of the major model parameters along with the model’s solution.

<table>
<thead>
<tr>
<th>Stage</th>
<th>$P_i$</th>
<th>$W_i$</th>
<th>$h_i$ (000s)</th>
<th>$\delta_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check in/out</td>
<td>88.4</td>
<td>26.4</td>
<td>151</td>
<td>0.48</td>
</tr>
<tr>
<td>Room</td>
<td>82.3</td>
<td>33.4</td>
<td>849</td>
<td>0.96</td>
</tr>
<tr>
<td>Restaurant</td>
<td>84.5</td>
<td>25.3</td>
<td>621</td>
<td>0.93</td>
</tr>
<tr>
<td>Breakfast</td>
<td>86.7</td>
<td>22.2</td>
<td>83</td>
<td>0.44</td>
</tr>
</tbody>
</table>

Table 1. Mean values of model parameters and solution.

After applying the framework we can make a number of recommendations to the service manager. The data suggest that satisfaction with the room, which is also the most important stage for customers, is lower than that observed in other stages. The model acknowledges this and given the manager’s fixed budget and that the cost to improve perceptions in the rooms is much higher than that of the remaining stages, it suggests that in order to improve overall perceptions, more resources should be placed in the remaining stages. The greatest improvement (small values of $\delta$) can be observed in the breakfast area, which although not the most important area to the customers, major improvements can be observed in an inexpensive way.

Since the robustness of the results depend on the reliability of the model’s parameters, we conducted sensitivity analysis. Sensitivity analysis can provide useful information to the service manager, in light of the fact that systematic biases may exist in the way some of the models’ parameters were determined.

4. CONCLUDING REMARKS

In this paper demonstrate the applicability of the SH modeling framework in practice. We discuss some of the practical difficulties associated with its implementation along with some novel ways to overcome them. We further discuss different issues which result from applying the SH in order to provide the service manager with optimal allocation decisions in multi-stage service delivery systems.

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A DYNAMIC MODEL OF COOPERATIVE ADVERTISING IN A MANUFACTURER AND RETAILER SUPPLY CHAIN

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ABSTRACT

Cooperative (Co-op) advertising is an interactive relationship between a manufacturer and a retailer in which the retailer initiates and implements a local advertising plan and the manufacturer pays part of the cost. It is often used in consumer goods industries and plays a significant role in market strategy for many companies. The continuous increase of spending volume and the growing importance of co-op advertising motivated us to explore the role of co-op advertising coordination and efficiency transactions between a manufacturer and a retailer.

The main reason for a manufacturer to use co-op advertising is to strengthen the image of the brand and to motivate immediate sales at the retail level (Hutchins 1953). The manufacturer’s national advertising is intended to influence potential consumers to consider its brand and to help develop brand knowledge and preference. Retailer’s local advertising is to stimulate consumers’ buying behavior. With the passage of time, it brings potential consumers to the stage of desire and action and gives an immediate reason to buy (brands being offered, specific prices, store location, etc.). Co-op advertising provides consumers the information needed when they move through the final stages of purchase and a congruence of information and information needs that would be impossible if the manufacturer used only national advertising (Young and Greyser 1983). In addition to the same objective, as the manufacturer, of immediate sales at the retail level, the retailer utilizes co-op advertising to reduce substantially its total promotional expense by sharing the cost of advertising with the manufacturer.

Most studies to date on co-op advertising have focused on a single period relationship where the manufacturer is a leader and the retailer is a follower, which implies that the manufacturer dominates the retailer. The design and management is the main subject (see, for example, Crimmins 1970 & 1985, Berger 1972, Dutta et al. 1995, Fulop 1988, Hutchins 1953, Somers, Gupta and Herriott 1990, Roslow, Laskey and Nicholls 1993, and Young and Greyser 1983). Little attention has been given to the recent market structure in which retailers retain equal or more power than manufacturers do in retailing (Achenbaum and Mitchel 1987, Buzzell, Quelch, and Salmon 1990, Fulop 1988, Huang and Li 2001, Huang, Li, and Mahajan 2002, Li et al 2002, and Yue 2006). This paper is intended to explore dynamic co-op behavior and to determine optimal brand name and local advertising efforts for the system members in a single manufacturer and a single retailer system dealing with a single product. Even though there are many other factors that may affect system members’ strategies (competitive effects, multiple manufacturers, multiple products, etc.), we focus our study on understanding dynamic co-op behavior in a two-member system because dynamic effects of immediate local advertising efforts and lagged brand name (national advertising) efforts are present even in the absence of other factors.

As noticed in Dutta et al. (1995), a co-op plan contains two principal components: a participation rate and an accrual rate. The participation rate specifies the percentage of local advertising costs that the manufacturer will share with the retailer and the accrual rate specifies the maximum local advertising costs for which the manufacturer will pay.

This paper attempts to investigate dynamic behavior of a manufacturer and a retailer in the context of co-op advertising. A two-stage game structure is applied in this investigation. At the first stage, the participation and accrual rates are determined. Then, at the second stage, the manufacturer and the retailer determine their own strategies independently, brand name investment efforts for the manufacturer and the local advertising costs for the retailer. Two scenarios are discussed regarding the first stage. In the first scenario, we assume that the manufacturer determines the participation and accrual rates independently. In the second scenario, it is assumed that both the manufacturer and the retailer make a joint effort to determine these two rates. Based on these two scenarios, two sets of dynamic equilibrium strategies are obtained. Comparisons and managerial implications of these two sets are offered.

There are three possible avenues for future research. First, the single manufacturer-retailer system assumption can be relaxed to a duopoly situation of manufacturers who sell their products through a common monopolistic retailer who sells multiple competing brands with varying degrees of substitutability. Second, in our analysis we employed nonlinear sales response function to satisfy the saturation requirement. As indicated in the literature of channel studies, many important results in equilibrium analyses depend on the shape of the product demand function (Moorthy 1988 and Shugan 1985). Therefore, the use of a S-shaped sales response function may yield different and interesting results in the analysis for co-op advertising agreements. Third, in our analysis, manufacturer and retailer prices are exogenous and uninfluenced by consumer advertising. This may rule out such cross-effects as the possibility of pull advertising being associated with products that provide retailers with slim margins. Future research may take this into consideration.

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Keywords: Co-op Advertising, Two-Stage Game, Dynamic Marketing Strategies, Retailing Strategies.

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Since the bibliography should include only those references cited in the text of the paper, it should be referred to as “References”. References should be listed at the end of the paper. Entries should appear in alphabetical order and should be numbered with the numbers placed in brackets (see example below).

The Internet-related developments have progressed, over the last two decades, from a simple static to dynamic web pages, textual to multimedia contents, and information browsing to video-conferencing, e-commerce, mobile-commerce and social networking. Facebook, MySpace, LinkedIn, Bebo and Twitter are other examples of social network sites (SNSs), whose impact on politics [1], business [2], knowledge management [3], and social networking and communications [4] cannot be underestimated.

It is estimated that US-based social network users will increase from 84.5 million people in 2008 to 164.9 million people by 2014 [5]. In a study conducted by Morpace Inc. [6] on 1,000 consumers who joined Facebook, 68% of them stated that a “positive referral from a Facebook friend makes them more likely to buy a specific product or visit a certain retailer.” As the number of SNS users continues to increase, retailers see SNS as a promising venue for target-marketing.

The SNS research topic has received a great deal of attention over the last few years with some focusing on online community group behavior [7] and others on the behavior of individual users [8]. This study focuses on the individual user perspective regarding the intention to continue using SNSs in the future. Our study contributes to the existing literature by examining the moderator variable educational background that is believed to be crucial in terms of online marketing and market segmentation. Collegiate major selection (IT major vs. non-IT major) represents an interesting variable—no prior study has explicitly investigated this variable. The choice of major could be important when determining the amount of help file and the degree of interface user-friendliness, or when providing user guidelines to various user-groups to customize their SNS web pages.

In order to achieve this, this study extends and combines the concepts of the unified theory of acceptance and use of technology (UTAUT) (see [9]), trust, motivation and interpersonal relationships, and IT educational background (i.e. computer skill and self-efficacy).

Surveys were conducted with more than 300 university students in Taiwan. All were offered extra credit (i.e. course marks allocation) if they agreed to participate. However, only 89% of them were valid responses. One hundred ninety-eight students (65.8%) were management information systems (MIS) juniors who had taken an introductory MIS course and were enrolled in the advanced course required for MIS undergraduates, while 103 students (34.2%) were enrolled in the introductory MIS course required for business administration (BA) undergraduates. The survey data was analyzed using the partial least squares (PLS) method as applied in [9, 10] when testing similar research models. The PLS software used in this study is SmartPLS [11].

Comparing the two groups of students mastering in management information systems (MIS) and business administration (BA), we found that the MIS group (with a relatively stronger IT education background) showed a significantly stronger effect of the positive influence of trust in technology, social influence and trust in the SNS community on the intention to continue using SNSs than did the BA group.

Although the t-values were not significant, the BA group (with a weaker IT education background) showed a stronger negative effect of effort expectancy as well as a stronger positive effect of facilitation conditions on the intention to continue using SNSs, as compared to the MIS group. In general, the BA group showed a stronger effect of positive influence of perceived enjoyment on the intention to continue using SNSs than did the MIS group.

These results indicate that collegiate major selection is an important factor that influences behavioral intentions to continue using SNSs through factors such as trust in technology, trust in the SNS community, facilitating conditions and effort expectancy.

Near-zero costs associated with SNSs attracts large numbers of user and visitors, similar to other online companies including Yahoo and Google. SNSs that provide interesting and enjoyable applications are better able to retain and/or increase user loyalty, and better manage relationships with users. However, satisfying all SNS users is complicated, as typical SNS users come from various diverse backgrounds. The results of this study attempt to equip service providers with a better understanding of the individual difference that influence users in terms of their intentions to continue using SNSs in the future. The individual-factor moderator examined here shows that differences pertaining to IT educational background impose different requirements and standards for facilitating conditions, perceived ease-of-use of the system, trust in the SNS technology and trust in the SNS community. SNS service providers should consider the feasibility of providing users with customized and dynamic SNS content and functionality based on their personal characteristics and security preferences.

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Abstract

Service-level agreements (SLAs) are widely observed in practice for managing suppliers’ performance. We study the roles of performance measures in SLAs using an application to inventory management. We consider two inventory performance measures: immediate ready rate (1 - stockout rate) and time-window ready rate, which are defined as the long-run percentage of periods in which demands are completely filled immediately or within a pre-specified time window, respectively. We identify situations under which an immediate ready rate results in close-to-optimal supply chain efficiency and situations under which a time-window ready rate is preferred, and find the roles of the time window in the SLA.

Keywords: service level agreement; delivery performance; time-window fulfillment rate.

EXTENDED ABSTRACT

With the increased outsourcing of manufacturing and services to suppliers comes a need for better contractual agreements between suppliers and buyers. One of the most widely employed contractual instruments is a type of performance based contracts called Service Level Agreements (SLAs). A survey by Obligore Inc. [3] in 2007 revealed that 91% of organizations use SLAs for managing suppliers, internal agreements, or external customer agreements.

SLAs are often used when the parties involved have a long-term relationship, where the transactions are not one time. Since a fixed price alone is not enough to guarantee the delivery of the required performance, positive and/or negative performance incentives are needed. For example, a penalty might be imposed when the supplier underperforms compared to some target service level. The penalty is not based on daily transactions but on performance over a period of time. Therefore, a fundamental issue in SLA design is what performance measure should be used to align a supplier’s incentive with the buyer’s objective.

Performance measurement has long been recognized as a central problem in principal-agent theory and has been extensively studied in the economics literature, but the performance measure considered there is generic with a simple form and not specific to any real-world application. The operations management researchers study performance measures for applied problems, but the focus is generally on the long-run expected value of a performance measure rather than its incentive effect. Thus it is of great importance to examine the role of a performance measure for specific operations management activities and its effectiveness for incentive alignment, and identify the appropriate performance measures to be used in an SLA.

To address the above research question, we consider an application of SLAs to inventory management and two common types of inventory service performance measures: immediate ready rate and time-window ready rate. Specifically, we study a single-item inventory system with a continuous-review base-stock policy, stochastic and stationary demand, and full backlogging. We consider a supply chain consisting of a single supplier and a single buyer, where the supplier can invest both in inventory and in the inventory replenishment lead time to achieve a service level target, and both investments are unobservable to the buyer. The supplier owns the inventory and incurs a linear inventory holding cost. For each delayed delivery, the buyer incurs a cost which is a convex and increasing function of the amount of delay. An SLA uses a multi-period review strategy, under which the supplier’s inventory performance is reviewed every R periods (called a review phase), and if it is below a pre-specified performance threshold, then the supplier will pay a penalty linear in the amount of performance deviation from the threshold.

Fill rate and stockout rate are inventory performance measures commonly used in both the practice and the literature. Most inventory management literature studies performance measures in the long run using expected performance. But the performance measure in a finite review phase is a random variable. When the supplier’s actions are unobservable, it is important to know the distribution of the performance measure in order to provide an incentive to the supplier. Since it is very difficult to derive the distribution of fill rate, we focus mainly on the ready rate, which is the long-run fraction of time that demands are filled immediately from the stock. It measures inventory availability, and is equal to 1-stockout rate. The conventional ready rate and fill rate are measures of the off-the-shelf or immediate order fulfillment performance. In practice, time-window fulfillment rates are more commonly used than off-the-shelf performance measures (LaLonde et al. [2]). In Quick Response and other forms of time-based competition, the performance measure for customer service is often the ability to meet delivery promises, where the promised time window is usually small. For example, around 1995, Hewlett-Packard aimed at a 93% fulfillment rate within 3 days, and IBM PC and Compaq 95% within 5 days (Hausman et al. [1]). When the performance measure is based on on-time delivery by a supplier to a buyer, time-window fulfillment rates are also used. Therefore, we also study another form of ready rate, the ready rate with a window, which is the long-run fraction of time that demands are filled within a window.
pre-specified time window. We study the ready rate for simplicity in exposition, but similar insights can be obtained when either the immediate or time-window fill rate is used as the performance measure.

The objective of this paper is twofold. First, we address the design of SLAs in supply management, including choosing the performance measure, and determining the performance target, the allowable performance deviation from the target, and the penalty for underperformance. Specifically, we examine two types of SLAs using either the immediate or time-window ready rate as the performance measure. Second, we compare these two forms of SLAs in terms of the average supply chain cost. We show that when the supplier employs a static inventory policy, can invest both in inventory level and in supply lead time, with the investments unobservable to the buyer, an SLA using the time-window ready rate can induce the supplier to make the investments compatible with overall supply chain optimization. An SLA using only the immediate ready rate generally cannot induce this first-best investment. We also discuss the issue of using a single performance measure for aligning the supplier’s incentive when the supplier has multiple ways to achieve inventory performance. We find that the time window in the performance measures plays three roles: (i) it aligns the supplier’s tradeoff between inventory and lead time investments with that of the supply chain; (ii) it allocates inventory risk between the buyer and a supplier; and (iii) to some extent it transfers the buyer’s delay cost structure to the supplier.

References

THE IMPACT OF THE PROPOSED STANDARD ON ACCOUNTING FOR LESSES ON REPORTED EARNINGS OF U.S. COMPANIES

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ABSTRACT

The purpose of this paper is to examine the proposed “principles-based” standard for accounting for leases that the U.S. Financial Accounting Standards Board (FASB) and the International Accounting Standards Board (IASB) are currently finalizing. This standard will be the first joint project undertaken by the two standard-setting bodies as they work towards a set of converged standards for the future. The current accounting standard in the U.S. is believed to be a perfect example of a “rules-based” standard that is open to manipulations. The proposed standard is designed to be “principles-based” allowing for the accountants’ and auditors’ judgmental determination of whether a lease should be accounted for as a capital lease or an operating lease. In this paper we examine the provisions of the proposed standard to study the impact on the reported earnings of U.S. companies.

Current accounting rules in U.S. distinguish between operating and capital leases on the basis of four very detailed criteria. If all four criteria are met, the lease is classified as a capital lease, resulting in the recognition of an asset and a liability in the financial statements. If any of the criteria are not met, the lease is classified as an operating lease which results in the payments being accounted for as rent expenses in the financial statement. As the criteria are very prescriptive, some critics of this standard believe it provides companies with an easy way to “design” the lease to avoid recognizing a long-term liability in the financial statement. In the wake of the financial reporting scandals at the turn of the century, some of the manipulations discovered involved leases. As the proposed standard will severely limit the recognition of operating leases, companies that currently use this method may to change the accounting treatment to recognizing capital leases. As yet, no study has examined the impact this change will have on the reported financial position of companies currently reporting operating leases. We identify U.S. public companies reporting rent expenses for leases and run proforma changes to the capital leases method to examine the changes this results in their reported earnings and the financial position.

REFERENCES

Made in Saskatchewan: An extension of country-of-origin branding exercise based on corporate social responsibility

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Purpose
The literature generally considers country-of-origin as an exogenous variable and examines its main effects on various consumer behaviors, or its interaction effects under diverse conditions. Little is known how certain country image, as a marketing variable, is formulated. The objective of this study is to document an action-based research project that purposefully branding products based on its location of origin. Drawing from Maslow’s hierarchy of needs, the authors consider alternative options of branding product of origin based on value, quality, or esteem, and propose that the new product origin branding initiative should incorporate corporate social responsibility, which appeals to the consumers’ highest level of needs: self-actualization.

Research Methodology
This paper is primarily qualitative. The authors draw on writings on topics such as corporate social responsibility, social entrepreneurship, and management of not-for-profit organizations to enrich the branding exercise primarily carried out by traditional for-profit businesses. To support their claims, the authors also present empirical evidence from several in-depth personal interviews with 17 senior managers from diverse industry backgrounds in Western Canada.

Conclusions
Country-of-origin, in this case, the product’s province-of-origin, is an important aspect of product characteristics. It can potentially serve as a cue to indicate value, quality, and other intrinsic characteristics that are difficult to measure or communicate. As the branding experience in the past have suggested, companies are more likely to enjoy higher level of price premium when their branding communication appeals to higher levels of consumers’ needs. Being socially responsible would appeal to consumers’ self-actualization need of doing the right thing, and represents future branding opportunities. Businesses can gain both social and financial benefits by becoming socially responsible. Corporate social responsibility provides competitive advantages to the business.

Value
Our findings have both theoretical and managerial implications. First, maintaining corporate social responsibility may generate a net economic cost to the organization in the short term, but one which is outweighed by the social and economic value it creates in the long term. Organizations need to invest some earnings in pursuing societal objectives. Second, depending on the organization’s effectiveness in aligning its social and business objectives, and communicating such dual objectives with its stakeholders, including customers, CSR can provide the organization with internal benefits in the form of competitive advantages and external benefits such as brand equity. Third, governments and business association play important roles in providing supports and incentives that encourage and facilitate organizations that create both economic and social value and promote such socially responsible behaviours.

Key words
Branding; country of origin; corporate social responsibility; market orientation; differentiation; competitive advantage; dynamic capabilities
An Airfreight Forwarder’s Aggregate Resource Planning under Uncertainty

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ABSTRACT

Airfreight forwarders are third-party logistics service providers who plan, coordinate and manage client shipments. They acquire airfreight spaces from three major sources: carriers (airlines), partners and subcontractors, all of which are different in terms of cost, flexibility and service reliability. Booking spaces directly from carriers is done several months in advance and is the cheapest. Under most situations, carriers do not allow any changes once the booking contracts are signed. Acquiring spaces from partners would cost more, and the available amount is typically smaller. But partners usually allow forwarders to finalize the bookings as late as one month before shipping time. International freight forwarding is greatly affected by fluctuating economic conditions. When shipping time arrives, forwarders could find themselves in need of additional resources or having surplus resources. For the former, forwarders may subcontract shipping requests to other industry agents; subcontracting cost is the highest, and the service reliability is typically the lowest. For the latter, forwarders may sell surplus resources to other agents.

An important concern of forwarders is whether the mix of bookings is indeed viable when implemented to meet individual shipment requirements. In this research, we provide a two-phase framework for this airfreight planning problem. The first phase is performed several months in advance and the second phase is performed close to the action time. In each timed phase, using the demand forecast at that time, a multi-item newsvendor model first determines, in aggregates, the resource requirements from carriers, partners, and subcontractors. A heuristic is then used to disaggregate the resource requirements into specific bookings. A simulation model simulates whether the bookings are viable during shipping time.

Keywords: airfreight forwarder, resource planning, demand uncertainty, optimization-simulation framework

Acknowledgements: This research was supported by an RGC grant (ref: 449210).
Developing risk-adjusted performance indicators for banking industry: A RM-eCRM framework

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Abstract
Profit and risk are the most important issues faced in the banking industry. Over the past two decades, the globalization of financial markets and institutions has created the increasingly competitive banking environment. The recurrence of banking crises, such as the subprime mortgage crisis in 2007-08, has induced significant impacts on economical activities. Facing the challenges, only about 10% of the banks claimed to achieve successful implementations of Enterprise risk management (ERM). Since Internet and IT change the business operations to create better chances and more challenges, Electronic customer relationship management (eCRM) is considered valuable for business organizations to sustain competitive advantages in electronic commerce. This article proposes an integrated conceptual model, named RM-eCRM, to incorporate the risk management concepts into the eCRM concepts. In this framework, the perspectives of Customer-centric risk-sensitive culture and Customer-oriented risk-adjusted management would facilitate appropriate technology use. The perspective of Risk-adjusted marketing capabilities mediates the association between RM-eCRM technology use and Risk-adjusted organizational performance through Customer interaction in the electronic commerce environment. This study contributes to a better understanding of the driving forces of customer interaction and risk-adjusted influences on important performance indicators in electronic bank marketing. Further research would adopt the confirmatory factor analysis (CFA) to develop the construct measures and structural equation modeling (SEM) for testing the proposed RM-eCRM framework.

Keywords: Enterprise risk management, Electronic customer relationship management, Structural equation modeling
CHALLENGE, INTERDEPENDENCE, AND GAMER LOYALTY

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ABSTRACT

The literature has identified social activities as the favorites of gamers, indicating that gamer loyalty may be associated with other games. This study utilized bilateral deterrence theory to identify interdependence among gamers as a determinant for gamer loyalty, and interdependence theory to identify challenge as a predictor for interdependence among gamers. This study found that (1) challenge is positively related to interdependence, (2) interdependence is positively related to gamer loyalty, and (3) challenge is positively related to gamer loyalty. This study suggests that game providers to raise gaming challenge, which improves gamer loyalty and increasing gamer interdependence.

Keywords: Online games, gamer, loyalty, challenge, interdependence.

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A MULTILEVEL APPROACH TO EXAMINING CONTINUANCE USAGE OF INFORMATION SYSTEMS

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Abstract

The user’s usage continuance of an information system (IS) has been considered as a key factor in determining whether an IS is useful or not. This usage continuance not only allows firms to recoup their IS investment but also represents the sustainability of IS success. However, continuance of IS usage is a long-term organizational process; it can be influenced by contingency factors (e.g., environmental and situational conditions) and has different effects on IS users. This paper attempts to apply the contingency theory approach to explore the complex relationship between IS effectiveness and user’s usage intention. Contingency factors usually are organization-dependent, thus we must examine their differences between organizations. For this purpose, we proposed a multilevel research model using hierarchical linear modeling (HLM) method. A sample of 485 IS users and 166 IS department employees from 47 firms was surveyed to verify our model. The findings have several implications for IS management.

Keywords: information quality, system quality, perceived load, perceived benefit, self-efficacy, service-oriented citizenship behavior, IS usage continuance.
EUROPEAN UNION: INTEGRATED POLLUTION PREVENTION AND CONTROL DIRECTIVE

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Abstract

The European Union (EU) directives for the next decade concentrate on sustainability and reduction of pollution at the source. The Integrated Pollution Prevention and Control (IPPC) Directive provides more flexibility in dealing with pollution by allowing different industries to use the best technologies suitable to their particular industry in dealing with pollution. The diversity allowed in dealing with pollution through IPPC Directive is a cornerstone of the new sustainability efforts of the EU.

This study examines the IPPC Directive in detail. The research focuses on some major industries of the EU (e.g., auto, tanning), examining the efforts of these industries to control pollution at the source. The paper also analyzes the impact of such flexible antipollution directive and discusses the benefits resultant from controlling pollution at the source to the companies, such as reverse logistics and reduction of the usage of raw materials and energy.
Innovation strategies of Taiwan Small and Medium CPA Firms – A Multiple Cases Study

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ABSTRACT

Due to the rate of change of technology and the economic environment, the CPA firms are experiencing significant instability and focused on expanding their services to their existing clients. The service innovation strategies become important. The purposes of this study is to develop a framework for assessing innovative service strategies and explore how the constructions affect service innovation strategies in the small and medium CPA firms. The research involves a series of case studies on small medium CPA firms in Taiwan. Research results find that corporate culture, CPA’s personality, information system, economic conditions and client’s requirements affect the service innovation strategies in the small and medium accounting firms. The small and medium-sized CPA firms should focus on their niche markets and effectively use their core resources to fit in with the changing environment.

Keywords: CPA firm, invocation strategy, case study
SUSTAINABILITY AS AN EMERGING COMPETITIVE CAPABILITY IN MANUFACTURING PRODUCTIVITY

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ABSTRACT

In general, the four basic capabilities in manufacturing strategy are quality, delivery, flexibility, and cost efficiency. These four capabilities are often used to analyze their trade-offs against each other in manufacturing productivity. Another view is that these four capabilities are cumulative in the above order and not necessarily in conflict with one another. Based on this concept, Ferdows and De Meyer proposed the sand cone model about 20 years ago. In this study, we revisit the model and discuss how sustainability can be an emerging competitive capability to measure manufacturing performance.

Keywords: manufacturing productivity, competitive capability, sustainability, sand cone model.
NURSE PROFESSIONAL COMMITMENT AND CARE QUALITY VARIATION

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ABSTRACT

Professional commitment influenced health care outcomes. However, none studies have investigated the link between professional commitment and care quality variation. Thus this study initiates in investigating how professional commitment and the variation of patient-perceived care quality. We found that professional commitment helps reduce variation in assurance, empathy, and tangibles. The findings provide novel means for improving health care outcomes.

Keywords: hospital nurse, professional commitment, care quality variation.

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MEANS FOR SUPERVISORS TO IMPROVE NURSE INTENTION TO HELP

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ABSTRACT

The previous studies indicated that interactions and communications among healthcare professionals are critical to care outcomes. This study thus adopted the perspective of social exchange theory and appraisal coping theory to investigate how Supervisor-nurse guanxi and negative mood of supervisors impact nurse intention to help colleagues. This study found that nurse intention to help colleagues is positively related to supervisor-nurse guanxi, but negatively related to negative mood of supervisors. Additionally, this study observed that nurse intention to help colleagues is positively associated with nurse agreeableness. The study findings can help supervisors to increase nurse intention to help colleagues that may help improve healthcare care quality.

Keywords: Guanxi, nurse, negative mood, agreeableness, intention to help colleagues.
AN EXPLORATORY STUDY ON THE EFFECTS OF A PHARMACEUTICAL COMPANY'S CSR ACTIVITIES ON DOCTORS' DECISION REGARDING PRESCRIPTION DRUGS

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ABSTRACT

In this study, we analyze the effects of pharmaceutical companies' CSR (corporate social responsibility) activities on doctors' decisions about prescription drugs using a qualitative approach. Our interviews with doctors suggest that pharmaceutical companies' CSR activities hardly influence doctors' decisions about prescription drugs directly. Instead, usefulness (i.e., efficacy and safety) is recognized to be the most important decision-making factor for prescription drugs in their specialized medical fields and the reputations of pharmaceutical companies in their non-specialized medical fields. The results also show that the CSR activities of pharmaceutical companies strengthen their reputations. In addition, our interviews with patients and their advocates reveal that patients' views about pharmaceutical companies' CSR activities are different from doctors' views.

Keywords: decision-making process, corporate social responsibility, pharmaceutical company, prescription drug, mammography examination caravan.
ABSTRACT

We study a dual sourcing problem in a two supplier, one buyer supply chain. We identify buyer's optimal sourcing decisions between the two suppliers that offer different contracts: quantify flexibility contract and quantity discount contract. We investigate how the buyer's optimal decisions will be affected by various contractual agreements. We discuss managerial implications and suggest future research opportunities.
ASYMMETRIC INFORMATION, TRANSACTION ATTRIBUTE, AND INTER-ORGANIZATIONAL CONTRACTING MANAGEMENT

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ABSTRACT

In practice, the formal contract plays a very important role in the inter-organizational transaction. This research tries to explore how the firm manages contract enforcement when facing asymmetric information on a transaction. We adopt case-study approach, and totally generate six transaction cases from five firms. The finding finds as follow. When one transactional party possesses asymmetric information on a transaction, the incentive-related clauses or safeguard-related clauses would be designed in advance and the firm intends to take some management process to reinforce or monitor the transaction.

Keywords: contracting management, uncertainty, case study
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