ADVANCED APPLICATION OF ANALYTIC HIERARCHY PROCESS: IDENTIFY AND INTEGRATE PERFROMANCE INDICATORS AND COST DRIVERS

Tai-Liang Chen

Department of Industry Engineering Management, ISU University

Feng-Chuan Pan*

Tajen Institute of Technology, & I-Shou University, taiwan.pan@msa.hinet.net

ABSTRACT

Going beyond the scope of traditional performance evaluation, BSC emphasizes a more balanced evaluation covering comprehensive aspects that affecting firm's business performance. BSC takes care of value drivers of financial and non-financial factors that closely associated with enterprise vision and strategy. Activity-Base-Costing (ABC) provides correct and instant costing information, the cost drivers. ABC has contributed great advantages to enable a more effective cost management. We propose a model to use analytic hierarchy process (AHP) to integrate key performance indicator（KPI）and cost drivers in one system Such a system will be able to deal simultaneously with internal and external environment, objective and subjective factors, critical value drivers and its associated cost drivers. This integrated system is expected to induce innovation, improve customer service, and enhance performance.

KEYWORDS: Activity-Based Costing (ABC), Balanced Scorecard (BSC), Key Performance Indicator (KPI), Analytic Hierarchy Process (AHP)

INTRODUCTION

Firms are now forced to involved complex factors in considering the evaluation methods on operation performance due to turbulent and fierce challenge. Activity-Base-Costing (ABC) system is widely applied in a wide variety of fields industry and academy, since it is able to clearly define the correlation between cost drivers and cost objectives (Cooper and Kaplan, 1988), and consequently rationalize the cost sharing problems. For example, ABC is applied in cost related problems in airline industry (Banker, *et al.*, 1993); in close circuit manufacturer (Hwang, 1995); in banking industry (Hsiao, 1998); and in logistics solutions (Caudle, 1999) etc. ABC provides accurate and relevant cost information in a timely manner, and enhance the firm to respond to the vast information needs under new manufacturing technology environment, such as information of manufacturing know-how as well as cross-national operation associated factors, e.g. foreign currency exchange, technology, and environment protection etc., thus make this costing system a superior techniques for firms cost related issues (Du, 1995). While ABC is advanced and powerful in detecting cost drivers, in rationalizing cost structures, and in upgrading an efficient cost system as mainstream of its application, it apparently has been ignored by both practitioners and academicians in trying to link with corporate strategies (Kaplan and Norton 1992).

Balance Score Card (BSC) was developed to involve corporate visions in the strategic

planning and actions through effectively integrating financial and non-financial functions with visions. BSC includes non-financial measurements such as customers, learning and growth, and business internal process other than conventional financial aspects (Kaplan and Norton 1992). Chow et al. (1997) characterized BSC as an important tool that aggregates traditional and strategic performance appraisal indicator by linking business strategy, structure, and visions in one system from which to offer useful assistance in implementing strategic goals and customer value in routine tasks and actions.

ABC is a useful method for firms to analyze activities and cost drivers of operations in the duration of production and sales procedures. This method aggregates all activity costs and amortizes it to respective cost objectives base on cost drivers. Efforts of this method are made to monitor the rationality of cause – effects relationship between cost driver and cost object. While this method is able to collect crisp cost information through rational cost amortization, it brought little guidance in forecasting where and what firms should perform for the future, nor incorporating with corporate strategy (Greenwood and Reeve, 1991；Kaplan and Norton, 1992) In the other hand, the balanced score-card (BSC) technique was developed to highlight financial and non-financial key performance indicators (KPI) of which a reliable tool top management adopts to clarify vision and strategy, to communicate and link strategic goals and measurements, to formulate indicators and to modulate strategic action alternatives, and to intensify strategic learning and feedback.

Although ABC and BSC are in practice well accepted as reliable tools for business operation, and it seems reasonable to adopt these two as integral for a better service to the top management and the firm per se, to our knowledge there are few if any scholar has done identical research. This research proposes that benefits to top management and firm would be multiple coming from advantage integration of respective models. It is also feasible to identify the significant KPI of respective dimensions, as well as the cost drivers of such indicators. First purpose of this research is attempting to identify the key impact elements and cost drivers, and to provide evidence through empirical testing. This new approach would be an innovative, reliable, and efficient decision-making methods that giving valuable decision-making criteria in a more reliable manner with better quality that spanning over financial and non-financial, internal and external, objective and subjective, and past and future performance aspects.

While descriptive statistics or regression analysis was adopted in most studies on critical success factor and performance appraisal, several researches have been conducted applying analytical hierarchy process (AHP) (e.g. Tseng and Wang, 1994； Lee and Cheng, 1996). As a multi-goals approach, AHP is generally applied in those decisions to be made with multiple criteria under an uncertainty scenario. A complicated system can be precisely presented by a simple and clear hierarchical factor structure of which categorized on a basis that concluded by experts and decision-makers (Saaty, 1980).

Another purpose of this research is to propose a model that integrating dimensions of finance, customer, learning and growth, and business internal process. It is a multi-goals targeting model that focuses on the decision-making problems where multiple criteria involved. It is appropriate for this research to adopt AHP in identifying key performance indicators (KPI) of four relevant dimensions. The associated cost drivers can then be determined with respective KPI consequently. There are thus two missions of this research to perform:

(1) Establish a service industry specific integrated model that consolidate activity-based costing (ABC) and balanced score-card (BSC)

(2) Identify key performance indicators (KPI) and associated cost drivers by using AHP method.

RESEARCH STRUCTURE

This research proposes a model that integrating ABC and BSC for service industry, shown as figure 1. KPI of the four dimensions are then identified by using AHP, and to obtain individual importance weight and cost drivers or operative activities of respective indices. We could then structure an effective and comprehensive assessment model for corporate (aggregate) performance.

Two stages are employed in this research, shown as figure2. We first identify as many as possible KPI of service industry that has been discussed journals recently. Several depth interviews with various executives are performed to identify relevant KPI. Colleagues of respective disciplines and practitioners who enlisted in Taiwan Who's Who corresponding to respective dimensions are invited to fill respective AHP questionnaires. Details are illustrated in later section Service businesses included are security service, restaurant, laundry, department stores, large-scale retailers, hospitals, business hotels, amusement parks, trading firms, and local bank.

To obtain better insight of such KPI, and to identify the most significant criteria for core operation from which resources could be appropriately allocated, ABC logic is then further applied to identify the cost drivers of each KPI through another depth interviews with relevant functional executives of services businesses. Positions of experts interviewed are ranging from front-desk supervisor of rather small firms to the CFO and CEO of larger corporations. Firm size, in terms of number of employee are ranging from 20 to 250.

Figure 1 Research Structure

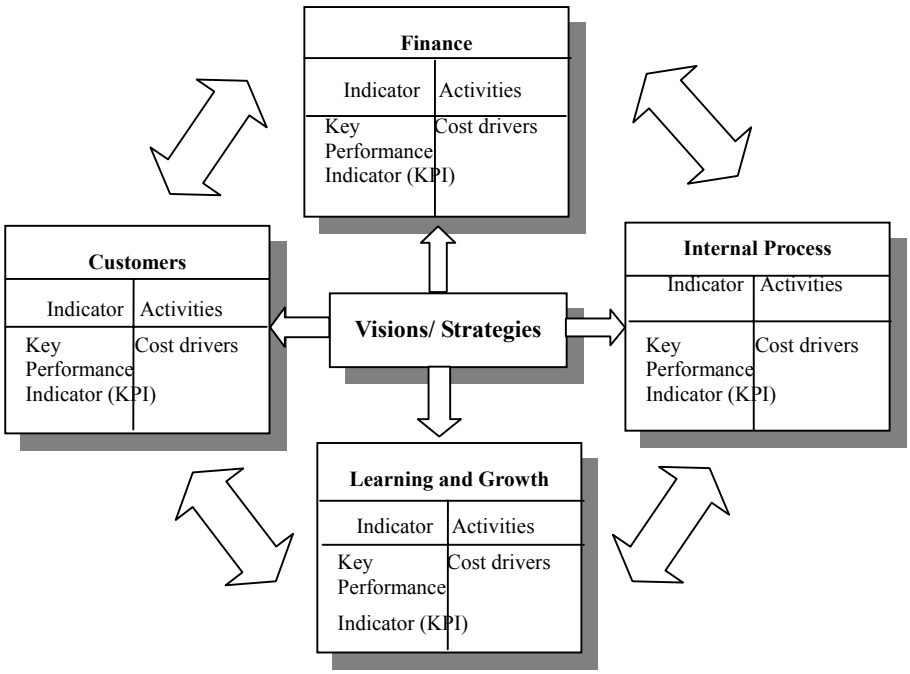
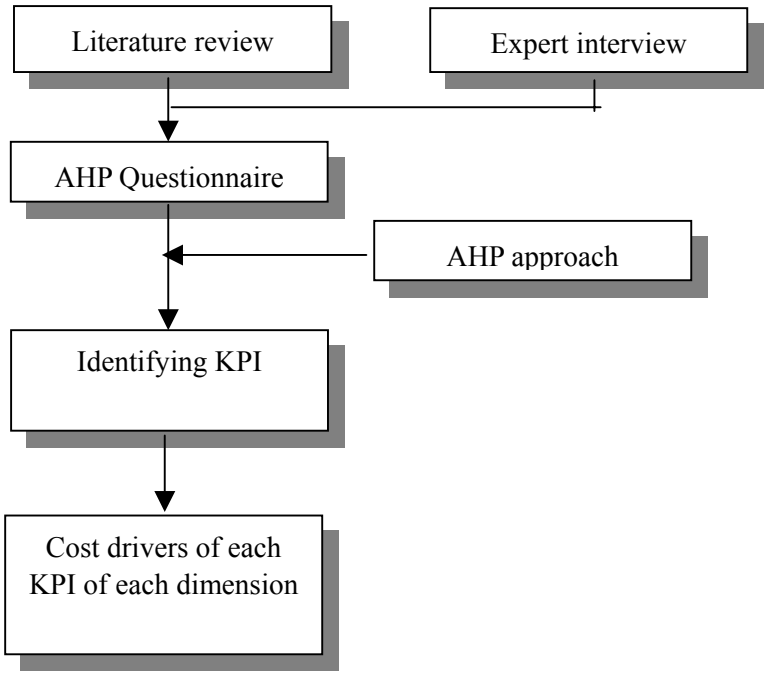


Figure 2 Research Process



ANALYTIC HIERARCHY PROCESS

This research adopts AHP method to explore the KPI of four dimensions of this BSC and ABC integrating model. Nine steps for data collection as recommended by Saaty (1980) are: (1) Defining problem, (2) Listing relevant criteria, (3) List all possible criteria, (4) Building hierarchical structure, (5) Designing AHP questionnaire, (6) Establishing pair comparison matrix, (7) Computing eigen-value and eigen-vector, (8) Consistency indicators and ratios, (8) Weight value of hierarchy, and (9) Extract the critical factors associated with problem to be solved.
An empirical study has bee done following the foregoing steps and illustrated in the following sections.

INDENTIFYING VALUE DRIVERS AND COST DRIVERS OF INTEGRATING MODEL

Establishing Hierarchical Structure

To establish aggregate model that integrating ABC and BSC for service industry, comprehensive evaluation is essential in finding KPI of all dimensions. Thus this research concluded relevant performance indices through literature review, depth interview, and shown as hierarchical structure in table 1.

Importance Weight of Factors of Respective Hierarchy

Professionals and scholars of respective dimensions were involved to answer the questions in the AHP-form questionnaire. Eigen value and vector, and consistence index (C.I.) were then computed and shown as tables 2 and 3. All CI in each hierarchy are lower than 0.1 indicates that respondents are rationale and consistent to the questions. It is apparent that questionnaire

and the result of this research would appropriately and thoroughly secure the professionals' views on performance indices (Fang and Hsu, 1999).

Table 1 Hierarchical structure of key performance indices

Dimensions	1st Hierarchy	2nd Hierarchy	
Finance	Revenue Growth	Growth of market size	Broaden business scope
		Growth of market share	Offering new product and services
		Develop new customers	Enhanced forced customer loyalty
	Margin Growth	Reduce variable cost	Adopt modern facilities
		Reduce fixed cost	Improve flow planning
		Reduce errors	Efficient education & training
Customers	Quantitative	Order processing efficiency	Providing relevant information
		Repairing efficiency	Door delivery efficiency
		Efficiency of goods returned	Service frequencies
	Qualitative	Attitudes of servants	Customer tracking
		Service scale and system	Customer claim handling
		Quality of showroom	Service flexibility
Learning and Growth	Institutional	Training & education system	Knowledge management mechanism
		Incentive and penalty	Performance appraisal system
		Corporate culture	Job measurement
	Operational	Quality of employee	Adapt capability of employee
		Learning capability	Productivity of employee
		Learning willingness	Relevancy of Training and job
Internal process	Logistics	Inventory efficiency	Stocktaking efficiency
		Logistic planning	Sorting strategy
	Procuring	Suppler selection	Inflow system
		Procuring strategy	Inflow quality control

Table 2 Importance weights of criteria in first hierarchy of each dimension

Dimension	1st Hierarchy	Vector	Order	Consistency	
Finance	Revenue growth	0.42	2	λ_{max}=2	
	Margin growth	0.58	1	C.I.=0<0.1	C.R.=0<0.1
Customer	Quantitative	0.69	1	λ_{max}=2	
	Qualitative	0.31	2	C.I.=0<0.1	C.R.=0<0.1
Learning and Growth	Institutional	0.6	1	λ_{max}=2	
	Operational	0.4	2	C.I.=0<0.1	C.R.=0<0.1
Internal process	Logistics	0.53	1	λ_{max}=2	
	Procuring	0.47	2	C.I.=0.06<0.1	
	Stocktaking	0.08	7	C.R.=0.04<0.1	
	Procuring	0.26	1		
	Picking	0.19	3		
	Dispatching	0.25	2		

DETERMINING KEY PERFORMANCE INDICATORS

Consistency testing across entire hierarchical structure is then computed after consistencies of respective hierarchies were achieved. Shown as table 4, consistence ration of hierarchy (C.R.H.) of all dimensions are lower than 0.1 of which indicates a high level of consistency across entire structure. Assured by the high consistency of questionnaire, the relative weight of each hierarchy factors could then be reckoned. Computation is ended at clearly determined KPI through comparison of weight loading. Any AHP importance weight values that larger

than 0.1 are included as KPI of particular dimensions in this research, shown as table 5.

Table 3 Importance weights of sub-criteria in second hierarchy of each criterion

Sub-criteria	Vector	Order	Sub-criteria	Vector	Order	Consistency
Finance (1st Hierarchy, Revenue growth)						
Growth of market	0.22	2	Broaden business scope	0.14	3	λ_{max}=5.90
Growth of share	0.38	1	Offering new product	0.06	6	C.I.=0.03<0.1
Develop new customers	0.08	5	Customer loyalty	0.12	4	C.R.=0.066<0.1
Finance (1st Hierarchy, Margin growth)						
Reduce variable cost	0.16	3	Adopt modern facilities	0.08	5	λ_{max}=5.98
Reduce fixed cost	0.06	6	Improve flow planning	0.34	1	C.I.=0.004<0.1
Reduce errors	0.26	2	Efficient education	0.10	4	C.R.=0.0032<0.1
Customer (1st Hierarchy, Quantitative)						
Order efficiency	0.38	1	Providing information	0.06	6	λ_{max}=6.26
Repairing efficiency	0.12	4	Door delivery	0.14	3	C.I.=0.052<0.1
Return efficiency	0.10	5	Services frequencies	0.22	2	C.R.=0.04<0.1
Customer (1st Hierarchy, Qualitative)						
Attitudes of servants	0.28	1	Customer tracking	0.16	4	λ_{max}=6.07
Service system	0.07	5	Claim handling	0.19	3	C.I.=0.034<0.1
Quality of showroom	0.06	6	Service flexibility	0.24	2	C.R.=0.015<0.1
Learning and Growth (1st Hierarchy, Institutional)						
Training & education	0.09	4	Knowledge mgmt	0.11	3	λ_{max}=5.84
Incentive and penalty	0.09	4	Appraisal system	0.27	2	C.I.=0.032<0.1
Corporate culture	0.08	6	Job measurement	0.34	1	C.R.=0.026<0.1
Learning and Growth (1st Hierarchy, Operational)						
Quality of employee	0.11	5	Application capability	0.21	2	λ_{max}=6.02
Learning capability	0.18	3	Employee Productivity	0.17	4	C.I.=0.004<0.1
Learning willingness	0.27	1	Relevancy of Training	0.06	6	C.R.=0.003<0.1
Business Internal Process (In / Out logistics)						
Space utilization	0.38	1	Facility usage capacity	0.16	3	λ_{max}=4.001
Loading of delivery	0.16	3	Time delivery	0.3	2	C.I.=0.0003<0.1
						C.R.=0.0003<0.1
Internal Process (1st Hierarchy, Logistics)						
Inventory efficiency	0.39	1	Stocktaking efficiency	0.15	1	λ_{max}=4.001
Logistics planning	0.29	2	Sorting strategy	0.17	3	C.I.=0.055<0.1
						C.R.=0.023<0.1
Internal Process (1st Hierarchy, Procuring)						
Supplier selection	0.21	2	Inflow quality control	0.17	4	λ_{max}=3.92
						C.I.=0.014<0.1
						C.R.=0.028<0.1

Cost drivers of KPI of respective dimensions deserved firms' great amount of attention since costs appear whenever actions are performed and interacted as indicated in table 1. Supply chain perspective views the entire value-added flow that delivers service to customers as internal business process. BSC, as a dynamic strategic managerial instrument, assumes that the four dimensions are interactive and interdependent. For example, quality of goods procured shall be improved prior to have a goal of cost reduction. To improve procurement quality, firms shall sharpen employee's techniques through training and education.

Consequently, customer satisfaction can be enhanced, market share could be jumped and cost could be eventually reduced (Kaplan and Norton 1996). This research hence assumes that cost reduction of service industry could be significantly achieved by an effective internal process control. The major contribution to the value created originates from procurement, inward logistics, and distribution of business internal process. It is therefore we direct our focus on the cost drives of the KPI of the dimension of business internal process.

Table 4 Summary of weight loading of dimensions

Dimensions	Criteria	AHP weight	criteria	AHP weight
Finance C.I.H.=0.021 R.I.H.=1.161 C.R.H=0.018<0.1	Broaden market size	0.0924	Broaden business scope	0.0588
	Growth of market share	0.1596	Offering new product and services	0.0252
	Develop new customers	0.0336	Enforced customer loyalty	0.0552
	Reduce variable cost	0.0928	Adopt modern facilities	0.0464
	Reduce fixed cost	0.0348	Improve flow planning	0.1972
	Reduce errors	0.1508	Efficient education & training	0.0580
Customer C.I.H.=0.04 R.I.H.=1.24 C.R.H=0.032<0.1	Order processing efficiency	0.2622	Providing relevant information	0.0414
	Repairing efficiency	0.0828	Home delivery and efficiency	0.0966
	Goods return handling	0.0690	Frequency and time of after services	0.1380
	Attitudes of servants	0.0868	Survey and follow of customer demand	0.0496
	Service scale and system	0.0217	Customer claim handling	0.0589
	Layout and neatness of display	0.0186	Flexibility of customer services	0.0744
Learning and growth C.I.H.=0.021 R.I.H.=1.24 C.R.H=0.017<0.1	Training & education system	0.0612	Knowledge management mechanism	0.0884
	Incentive and penalty	0.0952	Compensation system	0.1836
	Performance appraisal system	0.2108	Corporate culture	0.0408
	Quality of employee	0.0224	Employee satisfaction	0.0640
	Learning capability of employee	0.0576	Productivity of employee	0.0416
	Learning willingness of employee	0.1056	Consistency of Training and job	0.0288
Business Internal Process C.I.H.=0.091 R.I.H.=2.216 C.R.H=0.043<0.1	Inventory efficiency	0.2067	Stocktaking efficiency	0.0901
	Logistics planning	0.1537	Sorting strategy	0.036
	Supplier selection	0.0987	Quality control of inflow	0.0799
	Procuring strategy	0.2068	Inflow system	0.0846

KPI of internal process of service industry are found as quality of goods purchased and costs of dispatching. Challenges associated with ABC, as suggested by Lee and Ma (1996), mainly on the determination and choice of relevant cost drivers. In general cost drivers are determined by subjective judgment. This research embedded on Cheng and Chen (2000) along with extant depth interviews with scholars and practitioners, and concluded multiple cost drivers of each dimension

Table 5 Summary of KPI

Dimension	Key performance indicator (KPI)					
	1	AHP weight	2	AHP weight	3	AHP weight
Finance	Process improvement	0.1972	Increase share	0.1596	Reduce errors	0.1508
Customer	Order efficiency	0.2622	Service frequency	0.1380		
Learning and Growth	Appraisal	0.2108	Compensation	0.1836	Willingness	0.1056
Internal process	Procuring strategy	0.2067	Logistics planning	0.1537		

A model that integrating ABC and BSC is then established, shown as figure 1 Applying AHP in this particular model then identified KPI and importance weight of four dimensions, AHP technique is then applied in this model.

Proposition1：Key performance indicator of each dimension could be identified by jointly applied activity based costing and balance scorecard models. Second, customer loyalty, providing new services and process improvement are financial indices identified by applying the model that integrating activity based costing and balance scorecard.

Proposition1-1：Three KPI could be found by suing this integrating model: Improvement of production process, growth of market share, and reduce rate of error.

Proposition1-2： Two KPI of customer dimension, accuracy of order processing and time required for order processing could be properly identified by applying the integrating model that combines ABC and BSC.

Proposition1-3：Three KPI of learning and growth dimension, compensation system, appraisal system, and employee's learning willingness, could be determined by applying this integrating model.

Proposition 1-4：Two KPI of business internal process, quality of goods purchased and costs of dispatching could be found by applying this integrating model.

Proposition 2: Cost drivers of each KPI of each dimension could be identified by using this BSC and ABS integrating model.

Proposition 2-1: Improvement of production process is one of KPI of finance dimension, and its associated cost drivers could be determined by using this integrating model as scope, frequency of, and effects and incremental capacity incurred by the improvement.

Proposition 2-2: Growth of market share is one of KPI of finance dimension, and its associated cost drivers could be determined by using this integrating model as external marketing campaigns, expenses, and internal adjustment expenses etc.

Proposition 2-3: Reduce rate of error is one of KPI of finance dimension, and two associated cost drivers could be determined by using this integrating model: expenses associated with equipment updated, process improvement.

Proposition 2-4: Order processing efficiency is one of KPI of customer dimension, and key cost driver that is determined by using this integrating model is expenses associated with on

job training.

Proposition 2-5: Frequency and expiration of service warrant is one of KPI of customer dimension, and key cost drivers that are determined by using this integrating model are: coverage of service warrant, and quality of product.

Proposition 2-6: Performance appraisal system is one of KPI of learning and growth dimension, and key cost drivers that are determined by using this integrating model are: ways of performance appraisal, and its efficiency.

Proposition 2-7: Compensation system is one of KPI of learning and growth dimension, and key cost drivers that are determined by using this integrating model are: rational and human-oriented compensation system.

Proposition 2-8: Willingness of employee's learning is one of KPI of learning and growth dimension, and key cost drivers that are determined by using this integrating model are: learning effects and compensation associated with such learning.

Proposition 2-9: Three cost drivers of procurement strategy of internal process: frequency, problems associated with, and quantity of purchasing could be identified by using this integrating model.

Proposition 2-10: Inventory effect is one of KPI of internal process dimension, and key cost drivers that are determined by using this integrating model are: location, size, types, and storage method of inventory.

Proposition 2-11: Dispatching planning is one of KPI of internal process dimension, and key cost drivers that are determined by using this integrating model are: transportation vehicles, distance, frequency, dimensions, and weights etc.

CONCLUSIONS

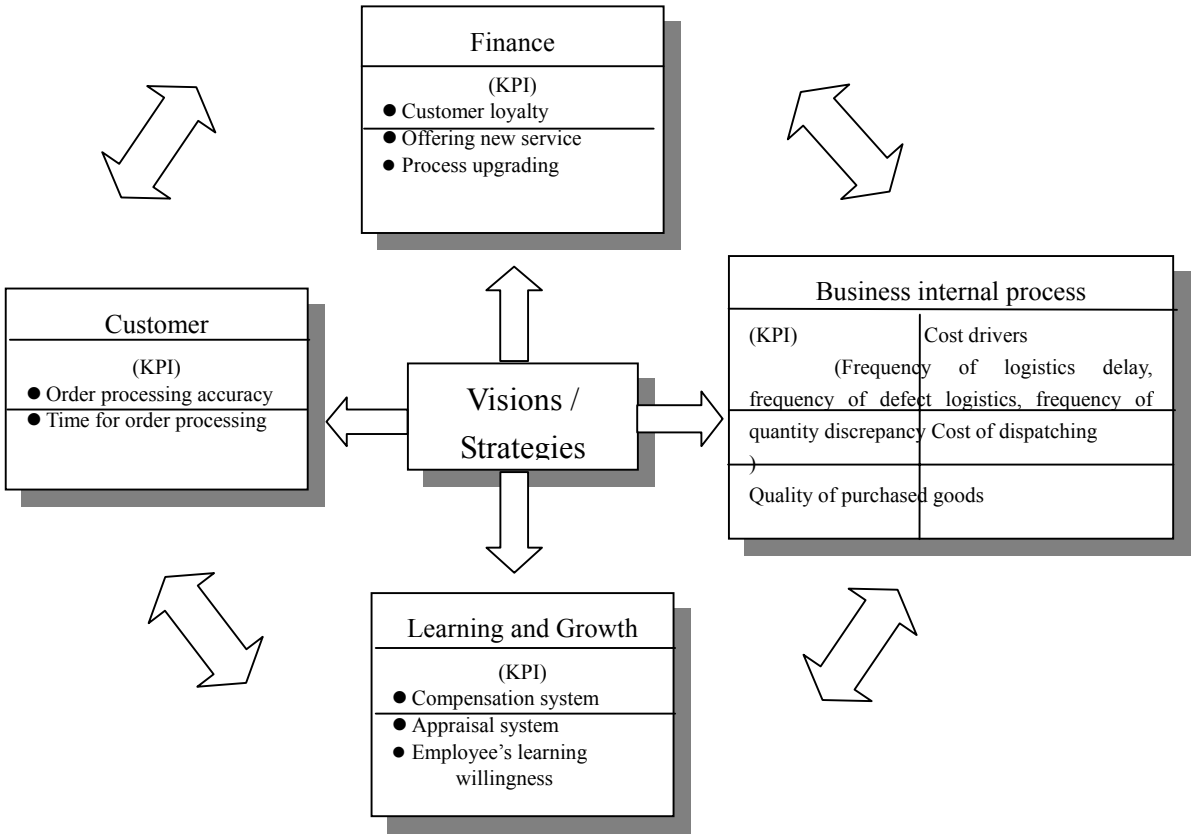
This research is the first integrates activity based costing and balance score card in establishing an integrated model specific for service industry. Taken the advantages of AHP technique, this model identify first the key performance indicator of four dimensions of firm, followed by identifying cost drivers of KPI of internal business process, illustrated as figure 3. Lee and Ma (1996) suggested that choice of cost drives is the main challenges of ABC model. Cost drivers of internal process dimension in this research are subjectively concluded from literature review (Cheng and Chen 2000) as well as several depth-interviews with scholars and practitioners of service industry. While this paper propose an innovative approach for firms to assess business performance in a more comprehensive and would be more efficient and effective way, further empirical survey and testing by using proper statistical methods would be necessary to improve the reliability and validity of this approach in determining cost drivers of service industry.

Further research may be conducted in determining the cost drivers of rest dimensions following the approach this research proposed. Contribution of this approach would be substantial by directing firm's resource investments in those value-added cost drivers, by linking corporate visions and strategy, and consequently enhance the operation efficiency and performance. Integrating approach jointly involved financial and financial, internal and

external, objective and subjective factors, and past performance and future expectations could be used as a strategic management instrument to substantially benefit the business performance.

Competition Taiwanese firms encountered are rapidly growing fiercer after Taiwan enrolled as regular member of the World Trade Organization (WTO). Accurately determining of product costs, effectively assess operation performance is now a major challenge to management. This research propose an innovative model in integrating the wide-accepted ABC and BSC system as one reliable tool by which substantially improve the effectiveness and efficiency of decisions making to the service industry. AHP can be particularly useful in helping managers to identify value drivers and cost drivers with confidence. And to consequently systematically structure by AHP the values pursued and costs associated will sharply ease the tension managers encountered in an increasing uncertain and complex business world. Compare to manufacturing sector, this integrating model would be exceptionally useful for service firms who engaged in frequent transactions with multiple customers that always required instant service delivery.

Figure3 Summary of Research Results



REFERENCES

Banker, R. D., and H. H. Johnson, "An Empirical Study of Cost Drivers in the U.S. Airline Industry," *Accounting Review,* (July), 1993, pp. 576-601.

Caudle, M. D. "Activity Based Costing Applications within logistics and their effects on logistics decision making," 1999, unpublished doctoral dissertation, Ohio State University

Cheng, Y. L., and H. C. Chen, "On the Establishment of Some Integral Productivity Index for the Operation of a Distribution Center," *Journal on Commercial Modernization,* l, 2000, pp. 46-60.

Chow, C. W., K. M., Haddad, and O. Williamson, "Applying the Balanced Scorecard to Small Companies," *Management Accounting,* 79, 1997, pp. 21-27.

Cooper, R. and Kaplan, R. S., "How cost accounting distorts product costs ? " *Management Accounting,* 1991, (April), pp.20-27.

Cooper, R. and R. S. Kaplan," Measure Costs Right: Make the Right Decision," *Harvard Business Review,* 1988, (Sep-Oct), pp. 96-103.

Cooper, R. and R. S. Kaplan,"Profit Priorities from Activity Based Costing," *Harvard Business Revie*w, 1991, (May/June), pp. 130-135.

Du, J. J., "Balanced Scorecard: Accounting Education and Innovation Perspectives," *Accounting Research*, 179, 2000, (October), pp. 12-13, *in Chinese*

Fang, K. D., and C. C. Hsu, "Location Decision of Convenient Shop—AHP Decision Model," *Journal of Technology*, 8, 1999, pp. 31-43, *in Chinese*.

Greenwood, T. G. and Reeve, I. M., "Activity Based Cost Management for Continuous Improvement: A Process Design Frame," *Journal of Cost Management,* 1991, pp. 42-48.

Hsiao, S. J., "Empirical Study of Cost Drivers and Operational Performance of Banking Industry," 1998, unpublished doctoral dissertation, National Cheng Chih University, *in Chinese.*

Hwang, H. L., "Application of Activity-Based Costing in Close Circuit Manufacturing-Case Study," 1995, unpublished master theses, National Taiwan University, *in Chinese.*

Kaplan, R. S. and D. P. Norton, "Putting the Balanced Scorecard to Work," *Harvard Business Review*, 1993, (Sep/Oct), pp.134-147.

Kaplan, R. S. and D. P. Norton, "The Balanced Scorecard: Measures that Drive Performance," *Harvard Business Review,* 1992, (Jan/Feb), pp. 71-79.

Kaplan, R. S. and D. P. Norton, "Using the Balanced Scorecard as a Strategic Management System," *Harvard Business Review,* 1996, (Jan-Feb), pp. 75-85.

Lee, J. H., and C. M. Ma, "Knowing What and Knowing Why: A Study of Effective Implementation of Activity Based Accounting and Managerial System," *Accounting Monthly*, 131, 1996, Oct, pp.88-93, *in Chinese*.

Lee, T. J, and C. H. Cheng, "Determining Success Factors of Logistic Centers by Analytic Hierarchy Process," *Taiwan Economic*s, 236, 1996, pp. 43-48, *in Chinese*.

Saaty, T. L. *The Analytic Hierarchy Process*, 1980, McGraw-Hill, New York.

Tseng, K. H, and J. T. Wang, "A Study of Performance Appraisal-Application of AHP and FMADM, "*Chung San Management Review*, 2, 1994, pp. 1-17, *in Chinese*.

Turney, P. B.B. *Common Cents: The ABC Performance Breakthrough*, 1991, Cost Technology, Hillsboro, Ore.