## An Empirical Study of the Impact of Information Technology on Firm Performance

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#### Abstract

Most previous empirical research has shown that the effect of IT on firm performance is minimal, negative, or mixed. However, these were simple bivariate analyses that did not consider contextual variables such as firm size or competitive factors. Additionally, their primary focus was on accounting-based performance, which was historical in nature. Industry effect on firm performance was also not examined. The purpose of this paper is to examine empirically the impact of IT on firm performance, considering several firm-level factors intervening IT impact. We also examine two major aspects of firm performance: accounting-and market-based performances. Finally, we identify differing impacts of IT on firm performance using four different IT spending measures. Our results clearly show that IT spending, measured in terms of the MIS budget, improves both account- and market-based performance measures. Combined with a more robust empirical design, which considered accounting- and market-based performances, contextual variables, and industry effect, this research could further illuminate the linkage between IT and firm performance.

### 1. Introduction

Information Technology (IT) improves the sharing of business information and the coordination of business resources both within individual organizations and across organizations [1, 2, 3]. Firms expect the use of IT to improve their business performance. According to previous research, however, IT does not improve firm performance. Most previous empirical research has shown instead that the effect of IT on firm performance is minimal, negative, or mixed [4, 5, 6, 7]. However, these were simple bivariate analyses that did not consider contextual variables such as firm size or competitive factors such as business strategies like product diversification and R&D. Taking these factors into account can change the relationship between IT investment and business performance. Most previous research has also focused on accounting-based performance measures such as return on assets [4, 6], the ratio of operating income to total assets [5], and the ratio of operating expenses to premium income [8]. Market-based performance measures such as Tobin's Q have rarely been used in previous research. Unlike accounting-based performance measures, which are historical in nature, market-based performance measures reflect investors' expectations about future performance.

This paper uses empirical techniques to examine the impact of IT on firm performance by considering several firm-level factors. We examine two major aspects of firm performance: accounting- and market-based performances. By controlling several firm-level variables such as firm size, capital intensity, R&D intensity, advertising intensity, product diversification, and industry effect, this study attempts to provide empirical evidence for performance improvements achieved by IT.

#### 2. Theoretical Background

Most previous research on the impact of IT on firm performance has examined the direct relationship between IT and firm performance. By examining the impact of IT on four accounting-based performance measures such as return on assets, return on net worth, profits as a percentage of sales, and average growth, Cron and Sobol [4] showed that the impact of IT was not significant; there was either very strong or very weak financial performance for firms with large IT investments. Stronger financial performance was found in larger firms where computers supported a breadth of activities. Turner [5] also found that there was no strong relationship between IT and organizational performance measures such as the ratio of operating income to total assets. However, no contextual variables were employed in his analysis. Bender [6] found a bi-modal relationship between IT investment and firm performance in the insurance industry. In their study of life insurance firms, Harris and Katz [8] found that IT was highly associated with firm performance—measured as the ratio of operating expenses to premium income. However, their results were quite weak at times, and they did not control for any exogenous variables. Based on a sample of large banks between 1979 and 1983, Markus and Soh [7] also examined the relationship between firm performance and a range of IT-related variables - including IT expenditure, extent of computerization, and proportion of IT services outsourced - while controlling for bank size and diversity of banking activities. They found that larger banks performed more poorly than smaller banks. But by studying the effects of IT spending lagged and accumulated over four years, they found that more extensive computerization was associated with greater firm profitability in larger firms than in smaller ones.

In aggregate, these studies show that on average IT has not improved firm performance. However, these studies have not considered contextual variables that might affect the impact of IT. In addition, their primary focus was on accounting-based performance alone, which was historical in nature. Market-based performance measures—reflecting investors' expectations about future performance—were rarely used to examine the impact of IT. Most of these analyses were also made for one industry, such as the insurance industry or the finance industry. Thus, industry effect on firm performance was not examined.

In summary, the question on the impact of IT on firm performance has not been clearly answered. To understand this impact better, we suggest a more robust empirical design that considers two major aspects of firm performance (accounting- and market-based performance), contextual variables, and industry effect. In the next section, we describe our empirical model, methodology, data and variable constructions.

## 3. Empirical Design and Methodology

## 3.1 Sample and Data Collection

The original data for this study were collected from the dataset of information systems (IS) spending collected annually by the International Data Group (IDG) between 1988 and 1992. The first 67 out of 605 firms were eliminated upfront because of insufficient data (missing data in a particular and/or outlying value). Then initial data were matched with economic performance and other control variables. Because our sample is a quasi-panel dataset and has missing values for some firms and years, we use aggregated averages of all the variables tested in this study. In addition, to assure generalizability and reliability of the results, the 453 firms (including financial institutions) were chosen on the basis of comprehensive data availability and tested for this study. Economic performance data (i.e., accounting- and market-based performances) and other controlling variables were taken from COMPUSTAT.

Industry	Count	SIC
Mining & Drilling	23	1000-1499, 2900-2999
Construction Industry	3	1500-1799
Food, Drink & Tobacco	29	0-999, 2000-2199
Textiles & Apparel	16	2200-2399
Lumber & Wood Product	27	2400-2699
Drugs & Chemicals	40	2800-2899
Rubber, Plastic & Leather	8	3000-3199
Glass, Cement & Stones	5	3200-3299
Primary & Fabric Metals	18	3300-3499
Machinery & Computer	25	3500-3599
Electric & Electronic Equipment	14	3600-3699
Transportation Equipment	27	3700-3799
Measurement Instrument	17	3800-3899
Transportation & Leisure Service	23	4000-4700, 7000-7099
Publishing & Communication	21	2700-2799, 4800-4899
Wholesales, Retailer & Food Service	46	5000-5999
Financial Services	77	6000-6999
Other Business Service	34	4900-4999, 7200-8799
Table	453	

## Table 1 Number of Firms in Samples by Type of Industry

#### **3.2 Description and Measurement of Variables**

To investigate the impact of IT on firm performance, the following proxies for the dependent variables, independent variables and control variables are employed.

## Information Technology (IT) Variables:

In order to identify the differing impacts of IT on firm performance, the following four measurements were taken from the IS spending data set to be used as proxies for IT spending: (1) IT activity as measured by the ratio of the total central IS budget to the selling & administrative expenses of the firm, (2) the MIS budget - the total central IS budget (labor expenses, materials, purchased services and software, and capital spending for the central IS department), (3) MIS staffs measured by the percentage of the MIS budget devoted to MIS staff (labor expenses), and (4) the number of PCs and terminals in use.

#### Performance Measures:

A common characteristic of past empirical studies on effects of IT is the use of accountingbased performance measures, which are historical in nature. Although these measures have been the primary focus of the past empirical research [9], market measures of performance should also be developed to reflect the market's perceptions of future performance [10, 11]. In order to gain more accurate results and to minimize possible weaknesses associated with the use of single-performance measures, this study considers two major aspects of firm performance: accounting-based performance and market-based performance. Three indices were employed to measure accounting-based performance: (1) return on average assets (ROAA), (2) return on average shareholders' equity (ROAE), and (3) return on average sales (ROAS). In addition to profitability indices, three market-based performance measures were also used to reflect the investor's expectations about future profit and to test the robustness of our results: (1) Tobin's Q, which is measured by the ratio of the sum of market value, preferred stock, and total debts to total assets, (2) market value, which is measured by the product of share outstanding and the year-end stock price, and (3) dividend-adjusted market rate of return, which is measured by the closing price at the end of the calendar month plus dividends per share by ex-date, divided by the prior month's close price.

## Control Variables:

In order to isolate the nature of the relationship between IT and firm performance, it is important to provide controls for other variables that are likely to have an impact on performance. To control for possible intervening effects, this study employs five control variables: firm size, R&D intensity, advertising intensity, capital intensity, and product diversification. These control variables are measured as follows: (1) firm size is measured by the natural log value of total assets, (2) R&D intensity is measured by the ratio of R&D expenditure to total sales, (3) advertising intensity is measured by the ratio of advertising expenditure to total sales, (4) capital intensity is measured by the ratio of the net value of plant & equipment to the total assets, and (5) product diversification is measured by the entropy measure introduced by Jacquemin and Berry [12]. The measure of total product diversification is a weighted average of the sales shares of the different four-digit SIC code industries, where the weight for each industry is the logarithm of the inverse of its share.

## **3.3 Empirical Model and Statistical Methods**

To investigate the effects of IT on accounting- and market-based firm performance, OLS multiple regression analysis was employed. This method is appropriate because the study is designed to explore the relative significance of IT and to identify the direction of its linkage with respect to diverse measures of corporate performance, while controlling for several variables such as firm size, R&D intensity, advertising intensity, capital intensity, product diversification, and industry-specific effects. The specific empirical models are as follows:

Performance (ROAA, ROAE, ROAS, Tobin's Q, Market Value, Market Rate of Return

 $= a_0 + b_1 (IT activity) + b_2(MIS budget) + b_3(MIS staffs) + b_4(No. of PC & Terminals) + b_5(Firm size) + b_6(Capital Intensity) + b_7(R&D intensity) + b_8(Advertising intensity) + b_9(Product diversification) + b_{10} (Industry sector) + e where$ 

- <u>ROAA</u> is the income before extraordinary items divided by the average of the current year's total assets and the prior year's total assets.
- <u>ROAE</u> is the income before extraordinary items divided by the average of the current year's shareholders' equity and the prior year's share holders' equity.
- <u>ROAS</u> is the income before extraordinary items divided by the average of the current year's total sales and the prior year's total sales.
- IT Activity is the ratio of the total central MIS budget including labor, materials, purchased services and software, to the selling & admin expenses
- MIS Budget is the natural log value of the MIS budget (the total central IS budget.

MIS Staff is the percentage of the MIS budget devoted to MIS staffs.

PC and Term is the number of PCs and terminals in use.

Firm Size is the natural log value of total assets.

<u>Capital Intensity</u> is the ratio of the net amount of plant and equipment to the total assets.

<u>R&D Intensity</u> is the ratio of R&D expenditure to total sales.

Advertising Intensity is the ratio of advertising expenditure to total sales.

<u>Product Diversification</u> is the entropy measure of total diversification.

The entropy measure of diversification was computed as  $\Sigma Pi \ln(1/Pi)$ ,

where Pi is the sales attributed to segment I and ln(1/Pi) is the weight for each segment i, or the logarithm of the inverse of its sales.

<u>Industry Dummy</u> is a dummy for the manufacturing and service industries where the firm is operating (1 for manufacturing and 0 for service industries).

## 4. Empirical Results and Analysis

## 4.1 Descriptive Statistics and Intercorrelations

Descriptive statistics for IT and performance variables are presented in Table 2. The MIS budget during the period is on average 3.949(\$51.883 mil.) and about 15.3% of the general administrative expenses was the portion of the total central MIS budget. 42.12 % out of the total central MIS budget is allocated to MIS staff's labor expenses. R&D and advertising intensity are 1.2% and 1.5% of the total sales revenues.

Variables	Mean	Std. Deviation
Accounting-Based Perform	ance	
ROAA	4.270	5.253
ROAE	11.012	38.819
ROAS	5.215	5.253
Market-Based Performance		
Tobin's Q	1.025	0.704
Market Value	7.568	5.427
Market Rate of Return	17.089	15.553
Information Technology (IT)	Variables	
IT Activity	0.153	0.032
MIS Budget (ln)	3.949	1.124
MIS Staffs (%)	42.122	1.214
NO. PC & Terminals (ln)	8.657	1.150
Control Variable		
Product Diversification	0.839	1.105
Firm Size (ln)	8.233	1.592
Capital Intensity	0.353	0.245
R&D Intensity	0.012	0.022
Advertising Intensity	0.015	0.032

# Table 2Descriptive Statistics of Variables in the Empirical Model:<br/>Mean and Standard Deviation

Note: ROAA is the Average return on Assets, ROAE is the average return on Equity, ROAS is the average return on Sales, Market Value is the product of share outstanding and year end stock price, IT Activity is the ratio of the total central IS budget to the Selling & Administrative Expenses, MIS Budget is the total central IS budget, MIS Staff is the percentage of MIS budget devoted to MIS staff, No. of PC & Term is the number of PCs and terminals in use, Firm Size is the natural log value of total assets, Capital Intensity is the ration of net amount of plant and equipment to the total assets, R&D intensity is the ration of the R&D expenditures to the total sales, Advertising Intensity is the ration of the advertising expenditure to the total sales, Product Diversification is measured by the Entropy measure.

Table 3 presents intercorrelations among the IT variables, various indices of performance measures, and control variables. For this analysis, the MIS budget and the number of PCs & Terminals in use are transformed into a natural logarithmic value. Apparently, the total central MIS budget, among other things, is positively and significantly (p<0.001) correlated with most performance measures except ROAE. But IT activity (measured by the portion of general administrative expenses) is significantly correlated only with the firm's market value. Product diversification is also highly significant (p<0.001) and positively correlated with most performance measures. Although we applied the "exclude cases listwise" method (i.e., only cases with valid values for all variables are included in the analysis) in dealing with the missing values for variables in our analysis, R&D intensity and advertising intensity are highly significant and positively correlated with various indices of performance measures.

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	1 0 0 0														
I. ROAA	1.000														
2. ROAE	.479***	1.000													
3. ROAS	.664***	.491***	1.000												
4. Tobin's Q	.709***	.414***	.372***	1.000											
5. Market Value	.382***	.247***	.463***	.327***	1.000										
6. Market Rate of Return	.158***	.386***	.290***	.218***	.159***	1.000									
7. MIS Budget (ln)	.163***	.417***	.338***	.016	.494***	.181***	1.000								
8. MIS Staff Budget (%)	.128**	.081	.064	.118*	027	.072	098*	1.000							
9. No. of PC & Terminals(1	n)019	.016	.062	.149***	.536***	009	.523***	121	1.000						
10.IT Activity	053	041	022	083	152**	.015	.074	025	.032	1.000					
11.Firm Size (ln)	083	.041	.282***	.180***	.687***	.120**	.465***	124**	.563***	097	1.000				
12.Capital Intensity.152***	012	.063	.246***	.186***	084	043	053	008	.109*	026	1.000				
13.R&D Intensity	.298***	.131**	.177***	.297***	.239***	050	.073	.079	.192***	061	.018	037	1.000		
14.Advertising Intensity	.269***	.240***	.119*	.347***	.166***	.105*	011	.073	005	088	056	047	.243***	1.000	
15.Product Diversification	.279***	.438***	.202***	.232***	.351***	.099*	.342***	.056	.177***	060	.201***	.120*	.165***	.112*	1.000
16.Industry Dummy	268***	051	.081	300***	021	.191***	.151***	052	.112*	.079	.258***	085	425***	243***	241***

 Table3
 Correlation Matrix for Variables in the Empirical Model

Significance Level: \* P<0.05; \*\* P<0.01; \*\*\* P<0.001.

Note: ROAA is the Average return on Assets, ROAE is the average return on Equity, ROAS is the average return on Sales, Market Value is the product of share outstanding and year end stock price, IT Activity is the ratio of the total central MIS budget to the Selling & Administrative Expenses, MIS Budget is the total central IS budget, MIS Staff is the percentage of MIS budget devoted to MIS staff, No. of PC & Term is the number of PCs and terminals in use, Firm Size is the natural log value of total assets, Capital Intensity is the ration of net amount of plant and equipment to the total assets, R&D intensity is the ration of the R&D expenditures to the total sales, Advertising Intensity is the ration of the advertising expenditure to the total sales, Product Diversification is measured by the Entropy measure.

#### 4.2 Results of Regression Analysis

Simple correlation results do not always reveal the same importance for variables as considering them simultaneously. Therefore, this pattern of intercorrelations should also be examined by multiple regression analysis. Using the OLS method of multiple regression, the empirical model shown previously was estimated separately with respect to each of the six indices of firm performance. The results of these regression analyses are presented in Table 4. All regression models were highly significant at the 0.001 level with respect to various performance measures. Hence, the multiple regression models are useful for exploring the relationships between IT and performance moderated by control variables. Each model examines the effect of IT activity on the firm's performance, after controlling for other related control variables.

Consistent with prior correlation analysis findings, the coefficient of the MIS budget is significantly positive at the 0.001 level (0.05 level with market rate of return) in most models with respect to accounting-based and market-based performance. Although it is slightly significant (P<0.05 for ROAA, P<0.01 for ROAS and market value, and P<0.1 for most other performance measures), IT activity (as measured by the portion of the MIS budget in administrative costs) is positive. This indicates that, as the firm's performance increases, the firm's focus on information technology is more likely to improve the firm's performance, regardless of different indices of performance measures. That is, the results of this study support the importance of information technology to build up a competitive edge in the market.

In addition, the coefficients of other control variable like R&D intensity, advertising intensity, and product diversification are statistically significant, at least at the 0.01 level, and positive with respect to most performance measures. Most important, product diversification is consistently significant and positive irrespective of various performance measures. That is, the results further support diversification strategy as one of the major determinants linking IT and performance. Finally, industry classification is only significant at ROAE and market-rate-of-return performance models. This indicates that industry effect is not likely to be a major factor in explaining the linkage between IT and performance with the possible exception the influence on shareholders.

Independent Dependent Variables: Performance Measures									
Variables	ROAA	ROAE	ROAS	TOBINQ	MKVAL	MKRTN			
IT Activity	0.1094*	0.2401**	0.0879+	-0.0788+	0.1003**	0.0892+			
-	(2.248)	(3.011)	(1.810)	(1.703)	(3.053)	(1.707)			
MIS Budget (ln)	0.2490***	0.4767***	0.3231***	0.1562**	0.1797***	0.1531*			
	(3.916)	(0.523)	(4.090)	(2.573)	(4.236)	(2.240)			
MIS Staffs	0.1021	0.0353	-0.0130	0.0750	0.0763*	0.0152			
	(1.036)	(0.827)	(0.263)	(1.646)	(2.366)	(0.285)			
NO. PC & Terminals	0.1274	-0.0543	-0.3118**	-0.2102***	-0.10031**	-0.1838*			
	(1.316)	(1.248)	(3.187)	(3.297)	(3.053)	(2.511)			
Firm Size (ln)	-0.1303*	-0.1803**	0.2608***	-0.1742**	0.3099***	0.1084			
	(1.971)	(3.100)	(3.950)	(2.813)	(4.342)	(1.524)			
Capital Intensity	0.1522**	0.0021	0.0119	0.2443***	0.2345***	-0.0506			
	(2.975)	(0.048)	(0.235)	(5.100)	(4.021)	(0.920)			
R&D Intensity	0.2158***	0.0866+	0.2562***	0.2425***	0.1448***	0.0087			
	(3.982)	(1.817)	(4.742)	(4.777)	(4.485)	(0.015)			
Advertising Intensity	0.1837**	0.2024**	0.1269**	0.2622***	0.1806**	0.1682**			
	(2.702)	(3.135)	(2.561)	(4.641)	(2.485)	(3.152)			
Product Diversification	0.1308*	0.3769***	0.2594**	0.1343**	0.0721*	0.1119*			
	(2.362)	(5.738)	(2.076)	(2.589)	(2.096)	(2.080)			
Industry Dummy	0.0021	0.1917***	-0.0130+	0.0434	-0.0260	0.2199***			
	(0.036)	(3.699)	(1.744)	(0.786)	(0.666)	(3.472)			
Adjusted R <sup>2</sup>	0.2239	0.3094	0.2266	0.3192	0.4607	0.132			
F-Ratio	10.897***	13.918***	11.053***	17.087***	27.405***	5.916***			

Table 4 Results of OLS Multiple Regression Analysis Examining the Relationships Between IT and Performance

Significance level: \* P<0.05; \*\* P<0.01; \*\*\* P<0.001

Note: ROAA is the Average return on Assets, ROAE is the average return on Equity, ROAS is the average return on Sales, Market Value is the product of share outstanding and year end stock price, IT Activity is the ratio of the total central IS budget to the Selling & Administrative Expenses, MIS Budget is the total central IT budget, MIS Staff is the percentage of MIS budget devoted to MIS staff, No. of PC & Term is the number of PCs and terminals in use, Firm Size is the natural log value of total assets, Capital Intensity is the ratio of the total assets, R&D intensity is the ratio of the R&D expenditures to the total sales, Advertising intensity is the ratio of the advertising expenditure to the total sales, Product Diversification is measured by the Entropy measure.

## 5. Conclusion

In this paper, we examined empirically the impact of IT on account- and market-based firm performances, and considered the intervening impact of variables such as firm size, capital intensity, R&D intensity, advertising intensity, product diversification, and industry effect. We analyzed the data using aggregate averages of all the variables for the five years from 1988 to 1992. Our results clearly show that IT spending, measured in terms of the MIS budget, improves both account- and market-based performances. Other IT spending measures—such as IT activity, MIS staff, and the number of PCs and terminals in use—have differing impacts on both firm performance measures. Other control variables such as R&D intensity, advertising intensity, and product diversification have a strong positive relationship with most performance measures.

The major contribution of this research is that it provides empirical evidence for the impact of IT on firm performance by using various IT and performance measures. By considering several firm-level variables that affect the impact of IT, this research demonstrates performance improvements achieved by IT. This research also shows that industry effect was not significant in explaining the impact of IT on firm performance. With a more robust empirical design, which considered accounting- and market-based performance, contextual variables, and industry effect, we could further illuminate the linkage between IT and firm performance.

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