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Understanding the Information Technology Innovation Impact on Firm Performance: An Empirical Investigation

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ABSTRACT:

This study revisits the impact of IT innovation on firm performance using the Information Week 500 databases and tests the robustness of innovation theory. Using the most recent dataset, this study not only compares performance of IT innovators with average industry performance but also compares it with a firm in the same industry and of similar size. It also compares performance of IT innovators from IT strategic industries with IT innovators from non-IT strategic industries. As expected, IT innovators performed better than the control group of all other firms within the same industry. However, there was no statistical difference between IT innovators and the control group of firms within the same industry and comparable size. IT innovators from transformational industries also fared better than IT innovators from either informate or automates industries. Therefore, our study confirms the strategic role of IT is an important factor on firm performance.

Keywords:

Information technology (IT) innovation, firm performance, organizational innovation theory, IT role

INTRODUCTION

Organizations invest a substantial amount in information technology (IT) as a means of improving their bottom-line. Researchers (Shin, 2007; Zhuang, 2005) have reported that IT investments alone do not increase the value of the firm. Instead, value is based on how IT is used within organization. The 2005 *InformationWeek* annual survey reported that the selected IT innovator firms in their survey improved organizational performance by using IT to accomplish tasks such as increasing automation, improving data integration between systems or departments, and/or reengineering existing applications (Cuneo, 2005).

This study focuses on innovation theory and the strategic role of IT. It revisits the impact of IT innovation on firm performance using the most recent Information Week 500 dataset and tests the robustness of the innovation theory. This study not only compares performance of IT innovators with average industry performance but also compares it with a firm in the same industry and of similar size. It also evaluates the impact of strategic role of IT on firm performance and extends our understanding on this topic.

ORGANIZATIONAL INNOVATION AND STRATEGIC ROLE OF INFORMATION TECHNOLOGY

IT Innovation

Organizational innovation research identifies the differences in the characteristics of early versus late adopters (Wolfe, 1994) and thus, it is useful for understanding relative innovativeness of an organization. Innovation is defined as the “adoption of an idea of behavior,” and it can be categorized as either administrative or technical innovation (Wolfe, 1994; Damanpour, Szabat, and Evan, 1989). Although there is not always a clear-cut difference between the two (Zmud, 1983), administrative

innovation is primarily based on the needs of management and indirectly influences the process of producing products or services or introduction of them. Conversely, technical innovation has a direct influence on the firm's product or service, which is important for organizational effectiveness (Damanpour et al., 1989).

Based on the premise that organizational innovation is increasingly important to stay competitive and become successful (Swanson, 1994), previous studies have investigated the relationship between organizational innovation and firm performance. Shin (2007) found a positive relationship between innovative use of IT and firm performance as it relates to past performance and revenue per employee. Although positive the relationship between IT innovation and return on assets (ROA) was not significant. This was partially attributed to the size of IT investments versus total assets or capital investments. Applying electronic business innovation to organizational innovation theory, Zhuang (2005) examined the relationship between innovative use of e-business and firm performance and found that firm performance of innovator e-business firms was significantly better than the average performance of all other firms with the same North American Industry Classification System (NAICS) code.. Firm performance was based on lower cost ratios and higher profit ratios. Note that Zhuang's study did not control firm size. We propose the performance of IT innovator firms is even better when compared to firm that are similar in size and operate in the same industry.

IT Role

Conceptualized by Schein (1992), IT strategic role is categorized as *automate*, *informatize up down*, or *transform*, depending upon IT-driven transformation efforts. The three categories of IT roles are described as follows.

- *Automate* IT role replaces expensive, unreliable human labor with information technology by automating business processes.
- *Informatize Up/Down* IT role provides information to higher levels of the organization more easily and efficiently to empower management and employees.
- *Transform* IT role fundamentally alters traditional ways of doing business by restructuring business processes and competitive forces of the industry where the firm operates (Chatterjee et al., 2001; Armstrong and Sambamurthy, 1999; Dehning et al., 2003).

As the industry moves from automate to transform, the level of IT-driven transformation changes from virtually none to the maximum. Using these categories, Armstrong and Sambamurthy (1999) examined IT strategic role at the firm level, while Chatterjee, Richardson, and Zmud (2001) examined it at the industry-level. Dehning, Richardson, and Zmud (2003) used these IT strategic role classifications from previous studies and found a positive return for firms that operate in industries with transform IT strategic role compared to firms in other industries.

Based on the above discussion, the following hypotheses are proposed.

H1:

The IT innovator firms have higher profit ratios and lower cost ratios on average when compared to the average performance of all other firms in the same industry.

H2:

The IT innovator firms have higher profit ratios and lower cost ratios when compared to the performance of a control firm that is similar in size and operates in the same industry.

H3:

The IT innovator firms in the transformative industries have higher profit ratios and lower cost ratios when they are compared to the average performance of other IT innovator firms that are not in the transformative industries.

RESEARCH METHODOLOGY

The "matched sample comparison group" methodology is used to investigate the impact of IT innovation on firm performance. It enables us to compare the performance of IT innovator firms with a control group of firms. This approach has been used in many previous studies (Bharadwaj, 2000; Santhanam and Hartono, 2003; Zhuang, 2005; Hunton, Lippincott, and Reck, 2003; Ko and Dorantes, 2006). Refer to the Data Source and Sample Selection section.

Firm Performance Measures

Firm performance was based on five profit ratios (ROA, ROS, OI/A, OI/S, and OI/E) and two cost ratios (COGS/S and SGA/S), which were also used in previous studies (Bharadwaj, 2000; Santhanam and Hartono, 2003; Zhuang, 2005). Note that the other studies also employed another cost ratio – total operating expenses/sales. However, we omitted that ratio since operating expenses include both cost of goods sold and selling & general administrative expenses, which are used in the other two cost ratios. The ratios and their formulas are shown in Table 1.

Performance Variable	Formula
Return on Assets (ROA)	Net Income / Total Assets
Return on Sales (ROS)	Net Income / Net Sales
Operating Income to Assets (OI/A)	Operating Income before Depreciation / Total Assets
Operating Income to Sales (OI/S)	Operating Income before Depreciation / Net Sales
Operating Income to Employee (OI/E)	Operating Income before Depreciation / Employee
Cost of Goods Sold to Sales (COGS/S)	Cost of Goods Sold / Net Sales
Selling & General Administrative Expenses to Sales (SGA/S)	Selling & General Administrative Expenses / Net Sales

Table 1. Description of Financial Performance Measures

Data Sources and Sample Selection

The initial dataset that we used is from the *InformationWeek* (IW) annual survey. In that survey, InformationWeek selects 500 companies that are considered “the most innovative IT organizations in the U.S.”. Criteria is based on innovation in business technology, not on the amount spent on IT.

Our study includes two sample groups: treatment and control. The treatment sample included those firms designated as “innovative IT users” in the *InformationWeek* annual survey for all three years from 2004 to 2006. For these firms, we pulled their financial data from *Compustat* for time periods 2003 to 2006. Any firm missing financial data for at least one of those years was excluded from the sample. As a result, the final treatment sample included 126 firms.

To test our hypotheses, we created two control sample sets. For each treatment firm, we selected all the firms that operated in the same four digit SIC code. The first two digits of a SIC code provide a general identification of a major industry or business, while the last two digits a more specific, providing classification of a given product or service within the industry. We also selected financial data from *Compustat* for time periods 2003 to 2006. Thus, one or more matching control firms were selected for each innovator firm. The average performance of these firms was calculated in order to compare it with the performance of the IT innovator firm.

The second control sample consisted of firms that operated in the same two digit SIC code as the innovator firm in the treatment group. Since total assets is a commonly used proxy for firm size (Hunton, et al., 2003), we selected a matching firm whose total assets were between 70 % and 130% of the innovator firm’s total assets. Thus, our control firm was comparable to firm size and industry of the treatment sample. We used the two-digit SIC code for this hypothesis because the sample size was not large enough to further break down the firms.. This is also why we used 70 to 130% range of total assets to classify firms according to size. It should be noted that this is an established and frequently used approach in previous studies (Barber and Lyon, 1996; Bharadwaj, 2000). The selected control firm was verified against the list of treatment firms to ensure that none of the control firms was included as innovator firms. Also, to assure the relative firm size of the IT innovator firms and the selected control firms were comparable to test H2, we carried out both a t-test and Wilcoxon test. No significant differences between the two groups were noted. Table 2 includes descriptive statistics of the IT Innovator and its matching control firms selected using both two digit SIC code and firm size. Table 3 provides the industry breakdown of the IT innovator firms.

Variable	IT Innovator Firms		Control Firms		t	Z
	Mean	Std. dev.	Mean	Std.dev.		
Total Assets (billion \$)	38.475	106.503	33.624	84.937	-0.878	-1.107

Variable	IT Innovator Firms		Control Firms		t	Z
	Mean	Std. dev.	Mean	Std.dev.		
Net Sales (billion \$)	10.594	20.410	10.133	19.046	-0.407	-1.992**

Table 2. Descriptive Statistics (Sample using 2 Digit SIC Code and Size)

** 5% level

SIC	Industry	No.	SIC	Industry	No
13	Oil and Gas Extraction	1	45	Transportation – Air	1
14	Mining & Quarrying of Nonmetallic Minerals	1	47	Transportation Services	1
15	Building Construction General Contractors	2	48	Communication	1
16	Heavy Construction	1	49	Electric, gas, & sanitary services	9
17	Construction Special Trade Contractors	1	50	Wholesale - Durable Goods	5
20	Diversified Foods Manufacturing	2	51	Wholesale - Nondurable Goods	2
23	Apparel & Other Finished Products	2	53	Retail - General Merchandise Store	1
25	Furniture & Fixture	4	54	Retail - Food Stores	1
26	Paper Products	3	55	Retail - Automotive	1
27	Printing and publishing	1	58	Food Service	2
28	Diversified Chemical Products	9	60	Baking	8
29	Petroleum Refining	1	61	Non-depository institutions	3
32	Diversified Building Material Manufacturing	1	62	Security & commodity brokers	2
34	Fabricated Metal Products	1	63	Insurance Carriers	9
35	Industrial machinery and equipment	10	70	Hotel & Lodging Services	2
36	Electronic & other electronic equipment	6	73	Business services	13
37	Transportation equipment	4	75	Automotive Repair & Services	1
38	Diversified Instruments	4	79	Recreation Services	1
40	Transportation – Railroad	1	80	Health Services	2
42	Transportation - Motor Freight	4	87	Engineering & Accounting	2
44	Transportation – Water	1			

Table 3. IT Innovators by Industry (two-digit SIC Code) (N=126)

RESULTS

Benchmark Control Firms – Industry Performance Average (Four-Digit SIC Code)

The t-test (parametric) and Wilcoxon tests (non-parametric) were used to evaluate if firm performance of IT innovators was better than the benchmark control firms selected using the four-digit SIC code. Compared to parametric t-tests that require normality and equal variance assumptions, non-parametric tests have much less restrictive assumptions concerning the distributions of the variables and the variances of comparison groups. They are also insensitive to extreme values or outliers. Thus, both t value and z value on the four year average are reported in Table 4. The results by each year from 2003 to 2006 are shown in Table A-1 in Appendix A.

Following the approach taken in the previous studies, a negative sign of test statistic indicates that the performance of the IT innovator firms is better than the control sample. Thus, negative profit ratios and positive cost ratios indicate that performance of the innovator group is higher than the control group. As shown in Table 4, profit ratios from the t-tests show that the innovator firms' performance measures are significantly better than the industry average except for operating income to employee (OI/E). Although the innovators' mean is higher, it was not statistically significant. Also, as shown in Table A-1, the OI/E ratio was not significant for any of the years in the study. Also note in Table A-1 that Return on Assets (ROA) and operating income to assets OI/A were not statistically significant in 2005, but were when compared over the 4 year span.

The two cost ratios from t-test were lower and significant overall (Table 3) and for each year in the study (Table A-1). The z values from the Wilcoxon test were significant in all corresponding profit and cost ratios and thus, our findings support the hypothesis that the average performance measures of IT innovator firms are better than the industry average performance. Thus, H1 is partially supported.

Overall Four-Year Average					
Ratio	Group	N	Mean	T	Z
Profit Ratios					
ROA	Innovator	126	0.04	-2.346**	-8.265***
	Control	125	-0.57		
ROS	Innovator	126	0.07	-4.013***	-7.872***
	Control	125	-2.07		
OI/A	Innovator	125	0.12	-1.928*	-7.413***
	Control	125	-0.45		
OI/S	Innovator	125	0.20	-3.857***	-7.647***
	Control	125	-1.79		
OI/E	Innovator	125	95.29	-0.728	-5.184***
	Control	125	72.02		
Cost Ratios					
COGS/S	Innovator	126	0.63	3.204***	4.170***
	Control	125	1.81		
SGA/S	Innovator	126	0.18	5.204***	4.996***
	Control	125	0.77		

Table 4. Performance Comparison of Group using the Primary SIC Classification (4 digit)

*** 1 % level ** 5% level * 10% level

Benchmark Control Firms – Industry and Firm Size (Two-Digit SIC Code)

Table 5 shows the results of the test of overall performance based on the four-year average when comparing IT innovators and their matching control firms (based on the two-digit industry SIC code and firm size). According to organizational innovation theory, average performance of IT innovator firms should be better than firms in the same industry and of similar size. However, contrary to our expectation, none of the t values or z values was significant. Even when we ran the analysis by each year, none of the performance ratios was significant. Thus, our findings did not support the hypothesis (H2) that average performance measures of IT innovator firms are higher when they compared to the performance of a control firm of similar size in the same industry.

Overall 4 Year Average					
Ratio	Group	N	Mean	T	Z
Profit Ratios					
ROA	Innovator	126	0.04	1.344	0.521
	Control	125	0.05		
ROS	Innovator	126	0.07	0.826	0.747
	Control	125	0.08		
OI/A	Innovator	125	0.12	0.731	0.729
	Control	123	0.12		
OI/S	Innovator	125	0.20	0.114	0.386
	Control	123	0.20		
OI/E	Innovator	125	95.29	1.147	0.301
	Control	121	126.83		

Overall 4 Year Average					
Ratio	Group	N	Mean	T	Z
Cost Ratios					
COGS/S	Innovator	126	0.63	0.452	0.034
	Control	125	0.64		
SGA/S	Innovator	126	0.18	-0.671	-0.429
	Control	125	0.17		

Table 5. Performance Comparison of Groups Using the Primary SIC Classification (2 digit) and Size

Strategic Role of IT – Transformative versus Other

Using the three categories of IT roles discussed in the earlier section, we classified IT innovator firms into two groups; firms in transformative and firms in other industries where IT plays either an automate or informate role, as described by previous research. Then, we compared the performance difference between these two groups. Results of the test comparing performance of IT innovator firms in the transformative industries with that of IT innovator firms in other industries are shown in Table 6.

Except for ROA and OI/A, t-test results show that profit ratios of IT innovator firms in transformative industries are statistically significantly better than those of firms in other industries. Note also that ratio of Selling and General Administrative Expenses to Sales (SGA/S) ratio is also not significant. However, Z values from the Wilcoxon test indicate statistical significance in all profit and cost ratios, which indicates higher performance of IT innovator firms in transformative industries. Accordingly, our findings partially support hypothesis H3.

All 4 Years					
Ratio	Group	N	Mean	t	Z
Profit Ratios					
ROA	Transform	223	-0.04	-0.812	-2.161**
	Other	644	-0.30		
ROS	Transform	223	-0.19	-3.423**	-4.274***
	Other	644	-1.15		
OI/A	Transform	222	0.04	-0.722	-3.049***
	Other	640	-0.22		
OI/S	Transform	222	0.02	-3.438***	-5.415***
	Other	640	-0.98		
OI/E	Transform	222	148.35	-3.091***	-2.614***
	Other	636	63.04		
Cost Ratios					
COGS/S	Transform	223	0.51	5.348***	10.726***
	Other	644	1.37		
SGA/S	Transform	223	0.44	0.247	3.372***
	Other	644	0.46		

Table 6. Performance Comparison of IT Innovator Between Transformative & Other IT Roles

*** 1 % level ** 5% level * 10% level

SUMMARY OF RESULTS AND DISCUSSION

Results of our study are summarized in Table 7. Although our three hypotheses are either partially supported or not supported, our findings suggest some important implications. While H1 is supported for all profit ratios and cost ratios other than operating income to employee (OI/E) ratios, this is not contrary to what we expected. We followed the same approach taken by previous studies and used industry average of firms operated in the four-digit SIC code as a benchmark. Firm size was not considered in this approach. Our findings are consistent with the results reported by Santhanam and Hartono (2003). When they conducted matched sample comparisons of firms using two the digit SIC code, OI/E ratios were not significant for 3 of 4 years from 1991 to 1994.

When we adjusted for the size factor to investigate H2, our results did not support our hypothesis. We found no significant differences in performance between IT innovator firms and a matching control firm of the same industry and of similar size. Based on innovation theory, we would expect IT innovator firms to perform better than the control firm when firm size and industry are controlled. However, our findings indicated otherwise. One possible explanation for this is that the *Information Week* dataset consists of firms with at least \$500 million in revenue (*Information Week*, 2005). Perhaps if this study was conducted on a broader range of firm size, including much small firms, results would have been different. Thus, further investigation is necessary to understand these contradicting findings.

To evaluate if a performance difference exists between firms with different IT strategic role, we investigated whether performance of firms that operate in transformative industries are better than firms in other industries. While the t-test statistic did not show significance in ROA, OIA and SGA/S, the Wilcoxon test shows statistical significance in all profit and cost ratios. Thus, our study indicates that performance of IT innovator firms that operate in the industries where IT plays dominant strategic role is better than those innovator firms that operates in industries where IT does not play a transformative role. The results of our study are consistent with the results reported by Chatterjee et al. (2001) and Dehning et al.(2003).

Hypothesis	Results	
H1	Partially Supported	On average, IT innovator firms have higher profit ratios and lower cost ratios when compared to the average performance of all other firms in the same industry except for the OI/E ratios.
H2	Not supported	When IT innovator firms of the same industry and similar size are compared, there is no significant difference in performance
H3	Partially supported	On average, IT innovator firms in transformative industries have higher profit ratios and lower cost ratios when compared to the average performance of other IT innovator firms in industries that are not transformative

Table 7. Summary of Results

CONCLUSION AND FUTURE RESEARCH DIRECTIONS

Based on organizational innovation theory, this study revisited the impact of IT innovation on firm performance and tests the robustness of innovation theory. Using the most recent dataset, this study not only compares performance of IT innovators with average industry performance but also compares it with a firm in the same industry and of similar size. While our results indicated that IT innovator firms outperformed the industry average in general, when firm size and industry are controlled, there is no significant difference in performance between IT innovator firms and control sample. This is contrary to the findings of previous studies and further research is needed to validate the innovation theory. For future research, one approach is to select all firms that are similar in size from the same industry, instead of selecting one matching company as used in our study. This might reduce any random errors in selection. Another approach is to select IT innovator firms that were identified as IT innovators by *InformationWeek* for 5 years or longer. We believe these approaches can help reduce any confounding factors that were caused from the sample selection process.

This research also investigates the strategic role of IT and determines if IT innovator firms in the industries where IT serves a transformative role perform better compared to innovator firms in either automate or informate industries. Our study indicates that performance of IT innovator firms is better for firms that operate in the industries where IT plays a dominant strategic (transformative) role than for firms that operate in industries where IT does not play a transformative role. The findings of our study confirm the strategic role of IT is an important factor on firm performance.

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APPENDIX A

2003					2004				
Ratio	Group	Mean	T	Z	Ratio	Group	Mean	t	Z
Profit Ratios					Profit Ratios				
ROA	Innovator	0.03	-4.506***	-7.638***	ROA	Innovator	0.04	-4.047***	-7.855***
	Control	-0.47				Control	-0.34		
ROS	Innovator	0.02	-4.117***	-7.843***	ROS	Innovator	0.07	-4.685***	-8.236***
	Control	-1.56				Control	-1.30		

OI/A	Innovator	0.10	-5.069***	-7.184***	OI/A	Innovator	0.12	-3.889***	-7.273***
	Control	-0.25				Control	-0.19		
OI/S	Innovator	0.16	-4.411***	-8.099***	OI/S	Innovator	0.19	-4.947***	-8.232***
	Control	-1.25				Control	-1.12		
OI/E	Innovator	72.51	-0.109	-5.824***	OI/E	Innovator	87.69	-0.399	-5.692***
	Control	68.44				Control	73.94		
Cost Ratios					Cost Ratios				
COGS/S	Innovator	0.64	3.139***	3.581***	COGS/S	Innovator	0.63	3.014***	2.700***
	Control	1.52				Control	1.41		
SGA/S	Innovator	0.21	3.272***	3.866***	SGA/S	Innovator	0.18	4.234***	4.345***
	Control	0.64				Control	0.81		
2005					2006				
Ratio	Group	Mean	t	Z	Ratio	Group	Mean	t	Z
Profit Ratios					Profit Ratios				
ROA	Innovator	0.04	-1.357	-7.860***	ROA	Innovator	0.06	-3.35***	-5.746***
	Control	-1.28				Control	-0.17		
ROS	Innovator	0.07	-2.826***	-7.282***	ROS	Innovator	0.09	-2.974***	-6.324***
	Control	-3.18				Control	-2.07		
OI/A	Innovator	0.12	-1.237	-6.982***	OI/A	Innovator	0.12	-3.110***	-5.689***
	Control	-1.26				Control	-0.06		
OI/S	Innovator	0.20	-2.466**	-6.907***	OI/S	Innovator	0.20	-2.862***	-5.989***
	Control	-2.83				Control	-1.78		
OI/E	Innovator	100.22	-1.359	-5.347***	OI/E	Innovator	130.34	-1.409	-3.785***
	Control	51.62				Control	84.47		
Cost Ratios					Cost Ratios				
COGS/S	Innovator	0.63	2.808***	3.170***	COGS/S	Innovator	0.63	2.476**	1.841***
	Control	1.92				Control	2.19		
SGA/S	Innovator	0.17	3.924***	4.816***	SGA/S	Innovator	0.17	2.897***	3.944***
	Control	0.97				Control	0.66		

Table A-1. Performance Comparison of Group by Year using the Primary SIC Classification (4 digit)

*** 1 % level ** 5% level * 10% level