Association for Information Systems
AIS Electronic Library (AISeL)

AMCIS 2007 Proceedings

Americas Conference on Information Systems (AMCIS)

December 2007

The Impact of Information Technology Innovation on Firm Performance

Namchul Shin
Pace University

The Impact of Information Technology Innovation on Firm Performance

Namchul Shin
Seidenberg School of CSIS
Pace University
nshin@pace.edu

Abstract

Since the issue of the productivity paradox was first raised in the early 1990s, a vast amount of empirical research has been done on the performance impact of IT. Much existing research has focused on IT investment even though value creation with IT depends largely on how it is used in organizations. By focusing on innovative uses of IT, this research empirically examines the relationship between IT innovation and firm performance. It uses Information Week's annual data set of innovative IT users and the Compustat database. To construct a measure of IT innovation, we develop a second-order construct from four IT innovation variables (technology strategy, e-business strategy, business practices, and customer knowledge) by conducting exploratory factor analysis. As measures of firm performance, we employ Tobin's q, return on assets, and revenue per employee. Our results show that there is a strong positive relationship between IT innovation and firm performance as measured by Tobin's q and revenue per employee. By using IT innovation data, this research demonstrates that innovative use of IT is an important link to IT value, which seems to be missing in the literature. Since simply putting money into IT does not automatically improve firm performance, the use of IT innovation, instead of IT investment, as a measure of IT can provide a means of examining the true value of IT.

Keywords: Information Technology Innovation, Firm Performance, Tobin's q, Organizational Changes

The Impact of Information Technology Innovation on Firm Performance

Introduction

The question of whether information technology (IT) contributes to firm performance has been debated extensively for the last decade. Much empirical research has been done on the performance impact of IT. A central focus has been solving the productivity paradox since the issue was raised in the early 1990s (Bharadwaj et al. 1999; Brynjolfsson 1993; Brynjolfsson and Hitt 1996; Brynjolfsson and Yang 1998; Santhanam and Hartono 2003; Shin 2001, 2006; Tam 1998). Much existing research has focused on IT investment, although creating value from IT is a complex process.

IT improves information sharing, decision-making, coordination, market orientation, product quality and variety, timeliness, customization, and convenience. Most of these benefits, however, might be difficult for companies to capture as direct economic value unless they make changes to processes, structures, and strategies. Simply putting money into IT does not automatically create economic value. The creation of value from IT investment depends largely on how it is used in organizations.

This research empirically examines the relationship between IT innovation and firm performance. IT innovation is an integrative concept that includes not only IT investment but also organizational changes in business processes and structures, which are complementary to IT investment. We employ the Information Week's annual data set of innovative IT users and the Compustat database. Information Week has identified 500 companies each year as "innovative IT users." Information Week's selection of the companies was not determined by how much IT was purchased, but by how companies use IT in their organizations. The data set includes IT innovation categories for each firm, such as technology strategy, e-business strategy, business practices, and customer knowledge.

Information Technology Innovation and Firm Performance

According to organizational innovation theory, innovation can be defined as the adoption of a new idea or behavior (Daft 1978). More narrowly, innovation can be seen as the first or early use of a new idea (Becker and Whisler 1967). An innovator is considered as the first or early adopter of an innovation (Swanson 1994). Based on this definition of innovation, IT innovation can be defined as the first or early adoption and use of new information technologies and business processes.

Swanson's Tri-Core model of information systems (IS) innovation (1994) classifies IS innovation into three categories: Types I, II, and III. According to Swanson (1994), Type I innovation is process innovation restricted to IS functional tasks, such as relational databases and CASE. Type II innovation is the use of IS to support administrative tasks, such as finance, accounting, and payroll. Type III innovation integrates IS with core business processes, such as ERP, SCM, and CRM systems. Type III innovations affect the whole business and have strategic relevance by offering competitive advantage to firms that are early adopters.

Innovation is the source of value creation (Schumpeter 1934). Schumpeterian innovation theory emphasizes the importance of technology and considers innovative use of technology as the foundation of new products and production methods (Zhuang 2005). According to Porter and Millar (1985), innovation can help firms alter the rules of competition, affect industry structure, and develop new ways of outperforming rivals, thus creating competitive advantage. Accordingly, we propose that IT innovation has a positive impact on firm performance.

Data Sources and Measures

This research employs the Information Week's annual data set of innovative IT users for two years: 2000 and 2001 and the Compustat database. Information Week has rated companies by the quality of IT innovations (technological, procedural, and organizational innovations), not by the amount of IT spending. The data set includes four IT innovation categories:

technology strategy, e-business strategy, business practices, and customer knowledge, scored at three levels (gold, silver, and bronze) for each firm based on "its early adoption and creative use of technologies and business practices" (Weston 2000). This specification is consistent with the IT innovation literature, which defines IT innovation as the first or early adoption and use of new information technologies and business processes (Swanson 1994). We treat these four IT innovation categories as first-order factors of IT innovation. Since these categories were developed by Information Week, we do not directly use them in our analysis. Instead, we develop a second-order construct of IT innovation and use it as a measure of IT innovation.

To construct a measure of IT innovation, we assign the numbers, 3, 2, and 1 to gold, silver, and bronze respectively and develop a second-order construct from the four IT innovation variables by doing exploratory factor analysis (principal component analysis with equimax rotation). According to Zhu and Kraemer (2005), such a second-order approach represents a theoretically strong basis for capturing complex measures. This approach is more rigorous than simply adding up the factors because it takes into account the appropriate weight of each factor (Zhu 2004). As measures of firm performance, we employ Tobin's q, return on assets (ROA), and revenue per employee. Data items are obtained from the Compustat database for the same firms included in the Information Week's data set.

Validity of the IT Innovation Variables

The Information Week 500 data set has been validated in part by Shin (2004). Observing the weaknesses of using the qualitative (perceptual) IT innovation variables, he showed their nomological validity. When the predicted relationship specified by theory is found to be significant, despite variations in measurement, then the instrument may be considered nomologically valid. He examined the relationships predicted by hypotheses, and his discovery of positive and significant relationships demonstrated the nomological validity of the IT innovation variables employed in his study. He also provided qualitative evidence of IT innovations by using case examples to corroborate the validity of the constructs.

Shin (2004) further states that although the survey instrument might lack academic rigor, it is probably relevant practically since the editing team of Information Week 500 has had experience in designing the instrument and collecting the data annually for over a decade. In general, large-scale secondary survey data such as the data set used in this study provide several advantages, such as providing a longitudinal database on various constructs not often available in other data sources, better response rate, participation of knowledgeable industry analysts and executives, and corroboration through qualitative reports and case studies (Bharadwaj 2000).

Methodology

To analyze the relationship between IT innovation and firm performance, an analysis of the combined data set for the two years of 2000 and 2001 is performed by using ordinary least-squares (OLS) regression.

The model measures the relationship between IT innovation and firm performance as measured by Tobin's q, revenue per employee, and ROA while controlling for diversification, capital intensity (capital investments/total assets), industry and year. The model also includes a one-year lagged variable of ROA to control for past performance since the performance impact of IT can be overestimated if there is no control for past performance (Santhanam and Hartono 2003; Tanriverdi 2006; Zhu 2004). We do not include firm size as a control variable because the model employs ratio variables for both dependent and independent variables. Dummy variables for each industry categorized by the SIC code and for each year are included.

$$\text{Performance}_{i,t} = \beta_0 + \beta_1 \text{IT}_{i,t} + \beta_2 \text{DIV}_{i,t} + \beta_3 \text{CAP}_{i,t} + \beta_4 \text{ROA}_{i,t-1} + \beta_5 \text{INDUSTRY}_{i,t} + \beta_6 \text{YEAR}_{i,t} + \varepsilon$$

IT stands for IT innovation. DIV stands for the Entropy index of total diversification. CAP denotes capital intensity. Performance represents firm performance measures that will be replaced in turn by each of the three performance variables: Tobin's q, revenue per employee, ROA. When ROA is employed as a dependent variable, the one-year lagged variable of Tobin's q is employed as a past performance variable. INDUSTRY and YEAR denote dummy variables for industry and year, which control for differences in industry characteristics and market trends respectively. ε is the residual term with zero mean, which captures the net effect of all unspecified variables.

Results

The second-order construct of IT innovation is estimated by conducting exploratory factor analysis. Table 1 shows the estimation of the second-order construct. The component loadings to the four first-order factors are of high magnitude, greater than .7, the cutoff suggested by Chin (1998). Cronbach's α is also greater than .7, providing satisfactory reliability (Nunnally 1978). The average variance extracted is greater than the suggested cutoff of .5 (Bagozzi and Yi 1988; Fornell and Larcker 1981). This indicates that variance in each of the four first-order constructs is sufficiently accounted for by the second-order construct.

Table 1. Estimation of the Second-Order Construct

Second-order construct	First-order construct	Component loadings	Average variance extracted	Cronbach's α
IT innovation	Technology strategy E-business strategy Business practice Customer knowledge	.720 .746 .712 .746	.54	.71

Note: Extraction method – principal component analysis with equimax rotation

Table 2 shows correlations of IT innovation and firm performance as measured by revenue per employee, Tobin's q, and ROA. The results show that IT innovation has a strong positive relationship with revenue per employee ($p<.05$) and Tobin's q ($p<.01$).

Table 2. Correlations

Variable	Revenue per employee	Tobin's q	ROA
Revenue per employee			
Tobin's q	-.053 (772)[1]		
ROA	.005 (946)	.421*** (778)	
IT innovation	.088** (575)	.094*** (482)	.000 (586)

Key: *** ($p<.01$), ** ($p<.05$)

[1] The values in parentheses are the number of observations.

Our regression results (Table 3) show that IT innovation is positively associated with firm performance as measured by Tobin's q and revenue per employee, but not by ROA. The positive relationship is significant for both performance variables. The coefficient of IT innovation indicates that the null hypothesis of zero effect of IT innovation can be rejected at a .01 confidence level for Tobin's q and at a .05 confidence level for revenue per employee respectively. The F values suggest that the overall model is statistically significant at the .01 level. The insignificant result on ROA implies that IT innovation may have little impact on how effectively a firm uses its capital investments or assets. One possible reason is that IT investment is small compared to total assets or capital investments. As a result, the performance impact of IT innovation may not be detectable with the ROA measure. Capital intensity, however, is strongly associated with an increase in ROA. Diversification is strongly associated with a decrease in Tobin's q, but with an increase in ROA.

Table 3. Regression Results

Independent Variables	Dependent Variables		
	Tobin's q_t	Revenue per Employee$_t$	ROA$_t$
IT Innovation$_t$	.109***[1] (2.644)[2]	.085** (1.950)	-.006 (-.129)
Diversification$_t$	-.155*** (-3.697)	-.015 (-.327)	.095** (2.146)
Capital Intensity$_t$	-.052 (-1.123)	-.095* (-1.587)	.250*** (5.876)
ROAt$_{i-1}$	.458*** (9.733)	.015 (.301)	
Tobin's q_{t-1}			.279*** (6.296)
Other Controls	Industry and Year	Industry and Year	Industry and Year
Adjusted R^2	27.1%	7.4%	22.0%
F Statistic	17.81***	5.02***	13.78***
N	454	508	453

*** (p<.01), ** (p<.05), * (p<.10)

[1] Standardized coefficients are reported.

[2] The values in parentheses are t-statistics.

Case Examples of IT Innovation

In an attempt to understand the nature of IT innovation, this section examines IT innovations undertaken in the companies selected as innovative IT users by the Information Week. The evidence from these examples can serve as indicators of IT innovation. For example, the operational CRM of Harrah's Entertainment indicates they have introduced IT innovations that have been very effective. By analyzing not only historical customer data but also customer behavior in real-time, the company has been able to provide better customer service and find ways to add value to customer experience, such as surprising them with special gifts and offers at the moment they hit a new royalty status. The operational CRM has also helped to address service problems in near real time. Harrah's changed CRM from something used to analyze customer visits into a tool for personalized, in-the-moment interactions (Anonymous 2006b).

Motorola's global supply chain management system provides another example illustrating how a firm uses IT innovatively. By integrating foreign suppliers into its global supply chain, the company designs, builds, and distributes products globally to meet growing customer demand. It also uses the Six Sigma program in conjunction with business process management software to design and automate solutions. According to Information Week (2006a), while many companies find offshore outsourcing to be an effective strategy for greater efficiency, some companies go beyond offshore outsourcing to pursue global opportunities. Global strategies include everything from having workers or subsidiaries outside the U.S to employing non-U.S. suppliers to build a global supply chain and perform overseas operations in real time.

Another company pursuing global opportunities through innovative IT use is Arrow Electronics, a global electronic components distributor. The company implemented a global wide area network (WAN) to eliminate the lag between requests for data and the beginning of data transfer between sales offices in regions outside the U.S. and its New York data center (Chabrow 2006). The company's global WAN established a direct connection—one-hop connectivity—between New York and all its sales offices.

Sun Microsystems' One Touch Program provides another illustration of IT innovation. The company operates a single global instance of its ERP applications, supply chain management software, and demand planning applications. The company simplified its IT architecture on the back end, giving it speed and flexibility. Using the One Touch System, the company could configure products for each order, rather than filling orders using predetermined products that may or may not be in its warehouses. A chief benefit for the company was the ability to close distribution centers in Asia, Europe, and the U.S. and cut inventory-handling costs (Whiting 2006).

In summary, the case examples of the operational CRM, the global supply chain management system, the global WAN, and the ERP systems blended with supply chain management and demand planning systems show that firm performance can be improved by IT when IT is used innovatively, that is, in conjunction with new business processes, strategies, and structures.

Conclusion

This study empirically examines the relationship between IT innovation and firm performance. As a measure of IT innovation, we develop a second-order construct from the four first-order IT innovation variables by conducting an exploratory factor analysis. As measures of firm performance, we employ Tobin's q, revenue per employee, and ROA. Our results show that there is a strong positive relationship between IT innovation and firm performance as measured by Tobin's q and revenue per employee.

This research views generating value from IT as a complex process of innovation associated with IT investment. By using the IT innovation data that entail both technological and organizational innovation, our work demonstrates that innovative use of IT is an important link to IT value, which seems to be missing in the literature. Since simply putting money into IT does not automatically improve firm performance, the use of IT innovation as a measure of IT, instead of IT investment, can provide a means of examining the true value of IT.

References

Anonymous. "Multiyear Comparisons of InformationWeek 500 Survey Data Reveal IT Trends," *Information Week*, September 12, 2006a.

Anonymous, "20 Great Ideas from InformationWeek 500 Companies," *Information Week*, September 12, 2006b.

Bagozzi, R.P. and Yi, Y. "On the Evaluation of Structural Equation Models," *Journal of Academic Marketing Science*, (16:1), 1988, pp. 74-94.

Becker, S.W. and Whisler, T.L. "The Innovative Organization: A Selective View of Current Theory and Research," *Journal of Business*, (40), 1967, pp. 462-469.

Bharadwaj, A.S. "A Resource-Based Perspective on Information Technology Capability and Firm Performance: An Empirical Investigation," *MIS Quarterly*, (24:1), 2000, pp. 169-196.

Bharadwaj, A.S., Bharadwaj, S.G., Konsynski, B.R. "Information Technology Effects on Firm Performance as Measured by Tobin's q," *Management Science*, (45:6), 1999, pp. 1008-1024.

Brynjolfsson, E. "The Productivity Paradox of Information Technology," *Communications of the ACM*, (35:12), 1993, pp. 66-77.

Brynjolfsson, E. and Hitt, L. "Paradox Lost? Firm-Level Evidence on the Returns to Information Systems Spending," *Management Science*, (42:4), 1996, pp. 541-558.

Brynjolfsson, E. and Yang, S. "The Intangible Benefits and Costs of Computer Investments: Evidence from the Financial Markets," *MIT Sloan School Working Paper*, 1998.

Chabrow, E. "In Depth: How the InformationWeek 500 Cracks Businesses Toughest Problems," *Information Week*, September 12, 2006.

Chin, W.W. "Issues and Opinion on Structure Equation Modeling," *MIS Quarterly*, (22:1), 1998, pp. vii-xvi.

Daft, R.L. "A Dual-Core Model of Organizational Innovation," *Academy of Management Journal*, (21:2), 1978, pp. 193-210.

Fornell, C. and Larcker, D. "Evaluating Structural Equation Models with Unobservable Variables and Measurement Error," *Journal of Marketing Research*, (18:3), 1981, pp. 39-50.

Nunnally, J.C. *Psychometric Theory*, McGraw Hill Co, New York, 1978.

Porter, M. and Millar, V. "How Information Gives You Competitive Advantage," *Harvard Business Review*, (63:4), 1985, pp. 149-160.

Santhanam, R. and Hartono, E. "Issues in Linking Information Technology Capability to Firm Performance," *MIS Quarterly*, (27:1), 2003, pp. 125-153.

Schumpeter, J.A. *Theory of Economic Development*, Harvard University Press, Cambridge, MA, 1934.

Shin, N. "The Impact of Information Technology on Financial Performance: The Importance of Strategic Choice," *European Journal of Information Systems*, (10:4), 2001, pp. 227-236.

Shin, N. "An Empirical Investigation of the Economic Payoffs of E-Business and CRM Innovations," *International Journal of Electronic Business*, (2:4), 2004, pp. 351-365.

Shin, N. "The Impact of Information Technology on the Financial Performance of Diversified Firms," *Decision Support Systems*, (41:4), 2006, pp. 698-707.

Swanson, E.B. "Information Systems Innovation among Organizations," *Management Science*, (40:9), 1994, pp. 1069-1092.

Tam, K.Y. "The Impact of Information Technology Investments on Firm Performance and Evaluation: Evidence from Newly Industrialized Economics," *Information Systems Research*, (9:1), 1998, pp. 85-98.

Tanriverdi, H. "Performance Effects of Information Technology Synergies in Multibusiness Firms," *MIS Quarterly*, (30:1), 2006, pp. 57-77.

Weston, R., D'Antoni, H., and Boomer, L. "Results Are Deeper Than Money," *Information Week*, 2000.

Whiting, R. "Sun Takes Built-To-Order to the Next Level," *Information Week*, September 12, 2006.

Zhu, K. "The Complementarity of Information Technology Infrastructure and E-Commerce Capability: A Resource-Based Assessment of Their Business Value," *Journal of Management Information Systems*, (21:1), 2004, pp. 167-202.

Zhu, K. and Kraemer, K.L. "Post-Adoption Variations in Usage and Value of E-Business by Organizations: Cross-Country Evidence from the Retail Industry," *Information Systems Research*, (16:1), 2005, pp. 61-84.

Zhuang, Y. "Does Electronic Business Create Value for Firms? An Organizational Innovation Perspective," *Journal of Electronic Commerce Research*, (6:2), 2005, pp. 146-159.