The Role of IT Investments in Fostering Firm Innovations: An Empirical Study

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Information Systems scholars and practitioners continue to devote more resources in trying to unravel how Information Technology (IT) investments create business value. Although there is an emerging consensus on the positive role of IT investments in creating business value, there is still a need for research studies that empirically examine the mechanisms or intermediate processes through which these IT investments lead to business value. This study examines the relationship between IT investments and firm innovation - one of the understudied mechanisms or intermediate processes in the IT business value paradigm. An investigation of this link identifies an important underlying mechanism that may explain how IT investments indirectly create business value. Using IT investments and innovation (patents) data, the researchers test hypotheses grounded in the Knowledge-Based View (KBV) theory of the firm. After controlling for firm and industry factors, the empirical results provide support for the effect of IT investments on firm innovation.

In the past four decades, Information Systems (IS) scholars and business practitioners have carried out a number of studies aimed at unraveling how Information Technology (IT) investments create business value. These studies have made significant contributions in the understanding of the relationship between IT investments and firm and industry level competencies (Banker et al., 2011; Tallon, 2010; Im, Grover, & Teng, 2013). However, there is still a need for research studies that investigate the mechanisms through which IT investments create economic rents in the firm. This research is motivated by the call for research studies that investigate the effects of business processes and, specifically, innovation through which IT investments create economic rents in the firms (Devaraj & Kohli, 2003; Melville, Kraemer, & Gurbaxani, 2004; Piccoli & Ives, 2005). Thus, the aim of this study is to empirically investigate the effects of IT resources on firm innovation, while taking the firm as the unit of analysis.

An investigation of the impact of IT investments on firm innovation is important because of the managerial implications that such results entail. For instance, various researchers have examined how IT interacts with other firm resources to spur performance differentials (Bhatt & Grover, 2005; Mithas et al., 2012; Tallon, 2010) and how IT returns are mediated by organizational processes such as customer satisfaction (Mithas, Krishnan, & Fornell 2005). The objectives of this study are closer to the aforementioned; although the scope goes beyond by incorporating firm innovation as the underlying mechanism through which firms earn above normal economic rents. Second, authors have called for "theoretical frameworks that explain how and why these [IT] investments" create business value (Sambamurthy, Bharadwaj, & Grover, 2003, p. 238).

This study addresses the above call by developing a theoretical framework that ties IT investments to firm innovation and specifically aligns the attributes of the knowledge based view theory of the firm to IT investments and innovation mechanisms. Strategically, innovation ranks among the top and most dominant initiatives associated with the rising levels of firms' IT investments (Ahuja, 2000; Teece, 2009). Many business managers have indicated that innovation is the engine of growth and the dominant driver of business value (Baya, Gruman, & Mathaisel, 2011). Innovation is the process through which new products, processes, business models, organizational frameworks, or services are thought out, developed, and brought to the market with the aim of generating economic rents, while satisfying customer needs (Katkalo, Pitelis, & Teece, 2010). For example, product innovations can lead to competitive advantages or expansion into new and emerging markets. Process innovations, through improvement in production efficiency, can create cost-effective production and marketing methods and services. Innovation has also been defined as the adoption of an idea, process, or behavior that is new to the adopting firm (Damanpour, 1996).

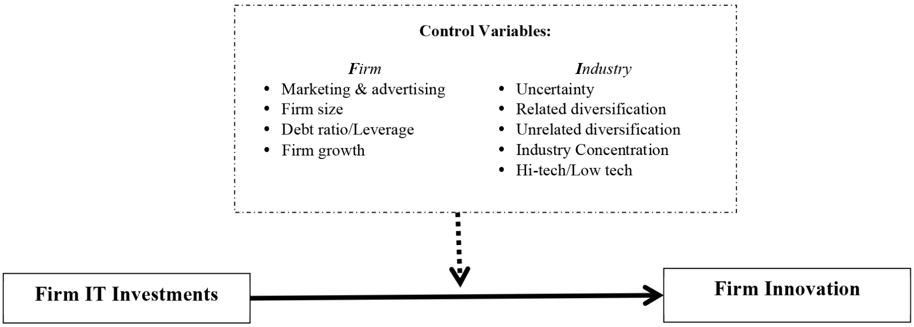
In spite of the importance of innovation in creating business rents, the extant research studies have not explicitly outlined which variables and business processes foster innovation leading to an inexplicable and confusing body of knowledge.

Thus, the goal of this research is to answer the following question:

What is the relationship between IT investments and firm innovation while controlling for specific firm factors such as growth, leverage, marketing and advertising intensity, and size, and industry-specific factors such as market share, diversification, role of IT in the industry, and environmental uncertainty?

To answer the aforementioned question, this study adopts IT investments data from *InformationWeek 500* and patents data, as a measure of innovation output, from the National Bureau of Economic Research (NBER). The values for the firm and industry control variables are generated from the Compustat dataset. In total, the panel dataset consisted of 483 global firms over a 7 year period (1991-1997). The research model is shown below in Figure 1.

Figure 1: *Research Model*



The IT investments and innovation model being tested in this research are not claimed to be exhaustive. It should be viewed as a parsimonious subset of a larger model since the complexity of organizations suggests that no single study could test all the relevant variables and their relationships. A parsimonious model was deliberately suggested that consisted of some of the key variables that may explain the relationship between IT investments and firm innovations.

Theoretical Background and Hypotheses

This study draws from the Knowledge Based View (KBV) theory of the firm to set up a theoretical framework. The main aim is to investigate the effects of IT investments on firm innovation while controlling for several salient firm and industry level factors.

Knowledge Based View Theory of the Firm

Knowledge Based View theory of the firm addresses how firms attain sustainable competitive advantages by using knowledge to build capabilities from resources. According to the KBV theory, organizational capability entails the ability of a firm to search, explore, acquire, assimilate, and apply knowledge about organizational resources, capabilities, and market opportunities (Grant, 1996; Kraaijenbrink, Spender, & Groen, 2010). Organizational capabilities are embodied in organizational technologies, business processes, product improvements, executive decision making, as well as organizational adaptations and renewal. Certainly, the more information and knowledge a firm can acquire from external and internal sources and competently distribute it within the firm, the more efficient a firm becomes in renewing and reconfiguring its resources and capabilities.

In line with the KBV theory of the firm, a number of studies have paid considerable attention to the concept of organizational dynamic capabilities (Helfat & Winter, 2011; Sambamurthy et al., 2003; Trkman, 2010). This line of inquiry has been motivated by the desire to address the increasingly important question of how organizations gain and sustain competitive advantages in complex and dynamic environments (Teece, Pisano, & Shuen, 1997). The mere existence of specific resources and capabilities is not sufficient to gain and sustain competitive advantage because changing environmental stimuli often demand new and innovative organizational responses.

As such, in order to gain and sustain a competitive advantage, an organization needs to reconfigure and recombine its resources and capabilities to meet the demands of a dynamic, uncertain, and fluid competitive environment. This particular process of reconfiguration and recombination has led to the concept of dynamic capabilities (Teece, 2009). According to Teece et al. (1997), dynamic capabilities refer to the processes through which organizations reconfigure and recombine their resources to gain the performance advantages. Dynamic capabilities are considered critical because they allow an organization to reconfigure and recombine its existing knowledge in such a way as to be able to respond to the challenges of complex dynamic environments (Katkalo et al., 2010) and can be captured through firm innovations.

IT Investments and Innovation

In many organizations, most of the business processes are either associated or fully embedded in sophisticated IT infrastructures. Thus, the strategic role of IT in the firm has led to an upsurge in IT investments (Mithas et al., 2012; Tallon, 2010). In the IT intensive firms, IT expenditures are almost 8% of total sales (Kobelsky et al., 2008) and almost 40% of the firm's total capital expenditures (Karanja & Patel, 2012; Ranganathan & Brown, 2006). Firms invest in IT because of the inherent ability of IT to provide important tools for knowledge management through the gathering, manipulating, and sharing of information and knowledge (Alavi & Leidner, 2001). These activities allow a firm to better understand the changes in the current environment and to reconfigure existing resources and capabilities for innovation and competitive performance in response to the changes in the internal and external competitive environments (Lopez-Nicolas & Merono-Cerdan, 2011).

In addition, IT resources enable a firm in augmenting its knowledge management capabilities (Joshi et al., 2010). IT resources not only facilitate the process of creating new knowledge through employees and stakeholders interactions, but also enable the process of knowledge reconfiguration and renewal. In addition, the sharing of knowledge within the firm creates synergies as IT can open several avenues to recombine and reconfigure knowledge from different perspectives that lead to innovation (Barbaroux, 2012; Joshi et al., 2010).

According to Zahra and George (2002), dynamic firm capabilities are closely related to the absorptive capacity of firms. Absorptive capacity, according to Cohen and Levinthal (1990), refers to the ability of a firm to acquire, assimilate, transform, and exploit knowledge. Acquisition and assimilation of knowledge are associated with the potential for absorptive capacity, while transformation and exploitation of knowledge represent realized absorptive capacity (Zahra & George, 2002). Since IT can be an important tool in supporting and enhancing a firm's knowledge acquisition capability by enhancing the speed, quantity, and quality of knowledge, it is likely that firms can get strategic benefits as a result of faster identification of useful knowledge that is important for the operations of the firm. For example, query-engines, expert systems, decision support systems, and many customized tools can capture and process information rapidly and accurately (Alavi & Leidner, 2001; Joshi et al., 2010).

Conversely, IT resources can also support a firm's capability in assimilating useful knowledge as part of the organizational memory. The assimilation capability allows a firm to compare information and thus make more informed decisions. The informed decision making is conducive to a firm's ability to generate new ideas, products, and services and eventually bring them to market to satisfy customers' needs and concurrently generate economic rents. Finally, IT resources can facilitate the exploitation of existing knowledge as well as the exploration of new knowledge. IT-enabled absorptive capacity involves knowledge exploitation by synthesizing and refining existing knowledge (Joshi et al., 2010). Conversely, knowledge exploration involves the transformation of knowledge through the merging of different databases, categorization and classification of knowledge frames, as well as by creating visual maps. Thus, IT resources can be an important tool for knowledge exploration and exploitation that eventually yields products, services, or business process innovations.

IT investments also contribute to the dynamic capabilities of the firm by providing resources that enable the recombination and reconfiguration of different knowledge domains. For instance, in the biotechnology industry, cooperation among different firms' networks is associated with new medical products and processes (Shan, Walker, & Kogut, 1994). Thus, the innovative ability and the resulting innovative output of a firm are dependent on the size of the direct and indirect ties that exist between the firm and its partners (Ahuja, 2000). Thus, it is argued that investments in IT resources provide platforms that enable and facilitate the interactions and collaborations among different stakeholders both within and outside the firm boundaries. The resultant inter-group and intra-group interactions and collaborations within and between organizations entail exchanging views, information, and ideas that help in generating knowledge, codification of useful knowledge, and informing processes (Prasanna, Hitt, & Brynjolfsson, 2012). Therefore,

H_0: *While controlling for salient firm and industry factors, IT Investments are positively related to higher levels of innovation in the firm*

Sample and Variables Used

In the following section, the constructs that are used in this study to test the model depicted in Figure 1 are defined.

IT Investments

There are multiple studies that have sought to extricate the complex relationship between IT investments, productivity, and firm performance (Melville et al., 2004: Prasanna & Hitt, 2012). A significant number of these studies have used different definitions and conceptualizations of the IT investments variable. The definition and the conceptualization of IT investments has varied based on whether the research data are obtained from a survey (Preston, Chen, & Leidner, 2008; Sobol & Klein, 2009), interviews with firm executives (Enns, Huff, & Golden, 2003; Leidner, Beatty,

& Mackay, 2003), or are gleaned from archival sources (Bharadwaj, 2000; Banker et al., 2011). Broadly defined, IT investments include all the expenditures made by the firm toward computers and telecommunications resources such as hardware, software, and related human resources and services (Dedrick, Gurbaxani, & Kraemer, 2003). Table 1 provides a short synopsis of some of the prior IS key research studies that have used the IT investments variable as well as the findings of these studies.

Table 1: *Key Constructs Used in a Subset of Prior IT Investment Studies*

Author(s)	Constructs	Results
Mithas et al., 2012	IT investments, profitability, operating expenses, sales, R&D expenses	IT investments positively impact firm sales and profitability through IT enabled revenue growth
Banker et al., 2011	IT investments, CIO (reporting structure, tenure	CIO reporting structure is based on firm's strategic positioning and they are associated with superior firm performance
Tallon, 2010	IT investments, customer intimacy, and operational excellence	Small firms strategically use IT for customer intimacy while large firms use IT mainly in operational strategies
Ravichandran, Liu, & Hasan, 2009	IT investments, diversification, performance	IT moderates the relationship between diversification and performance
Shin, 2006	IT intensity (IS budgets scaled by selling and general administrative expenses)	Interaction term of IT and strategic direction is positively associated with gross margin and IT is negatively associated with firm performance
Zhuang, 2005	E-business innovation (early adoption and creative use of electronic commerce technologies)	Significant differences exist between the performance of e-business innovative firms versus the performance averages for their respective industries)
Devaraj & Kohli, 2003	Costs associated with DSS (IT labor, capital, and support)	Support for the IT-Performance relationship after certain time lags
Brynjolfsson, Hitt, & Yang, 2002	IT spending (installed IT base, Total CPUs, # of PCs)	Financial markets put a higher value on firms with more installed computer capital (combination of computers and organizational structures creates more value)
Zhu & Kraemer, 2002	E-business use (the extent to which e-business is being used to conduct value chain activities)	Important antecedents of e-business use are technology competence, firm size, financial commitment, competitive pressure, and regulatory support
Bharadwaj, Bharadwaj, & Konsynski, 1999	IT spending (staff expenditures, hardware, software, and data communications)	For all five years, IT investments had a significantly positive association with Tobin's q value.
Francalanci & Galal, 1998	IT expense (ratio of firm-level IT expenses to total premium income)	Increases in IT expenses are associated with productivity benefits when accompanied by changes in worker composition
Loveman, 1994	IT spending (investments in Hi -Tech capital resources like office, computing and accounting machinery)	IT capital had little, if any, marginal impact on output or labor productivity
Weill, 1992	IT Investment perceptually categorized by management objective (strategic, informational, and transactional)	Heavy use of transactional IT investment is significantly and consistently associated with strong firm performance over the six years studied. Heavy use of strategic IT is neutral in the long term and is associated only with relatively poor performing firms in the short term
Strassmann, 1990	IT spending (IT investment budgets, value of installed equipment, IT staff budget, # of PCs and terminals)	Relationship between expenses for computers and business profitability is not consistent
Cron & Sobol, 1983	Organizational Strategy and computerization	Computerization is related to overall performance

This study adopted the definition of IT investments that was used in the InformationWeek 500 industry magazine (Lou, 1997), in which IT investments included all those expenditures relating to a firm's IT infrastructures such as PCs, servers, mainframes, communication equipment, software, and other related hardware that are utilized in setting up local and wide area networks, as well as expenditures incurred toward hiring and training IT employees and providing related services. IT investments data from InformationWeek 500 firms has been used extensively in IS research in exploring the various dimensions of IT and firm variables (Banker et al., 2011; Ravichandran, Liu, & Hasan, 2009). Table 2 shows a sample industry breakdown of IT investments into 6 major categories, namely salaries and benefits, hardware, software, IT services, research and development, and others.

As Table 2 illustrates, the allocations of IT investments across the industries and specific firms in each industry do not vary greatly. The values listed are in percentages.

Table 2: *2008 Industry % Allocations of IT Investments*

Industry Groupings	Salaries & Benefits	Hardware	Software (purchases, development & maintenance)	IT services	R&D	Everything else (includes system administration & maintenance)
Information Technology	29	19	19	13	3	17
Manufacturing	38	14	17	14	5	12
Banking/Financial Services	32	20	20	12	5	11
Automotive	28	18	23	21	3	7
Biotech./Pharmaceuticals	30	11	20	29	5	5
Chemicals	31	16	27	16	1	9
Construction/Engineering	37	20	18	11	4	10
Consulting/Business Firms	33	17	19	13	5	13
Consumer Goods	35	10	22	15	3	15
Insurance	44	14	15	14	3	10
Hospitality and Travel	34	16	16	17	3	14
Healthcare and Medical	34	17	20	9	4	16
Energy Utilities	32	15	23	14	2	14
Electronics	32	19	17	18	6	8
Distribution	36	13	16	17	4	14
Logistics/Transportation	30	15	22	17	3	13
Media and Entertainment	31	18	27	12	2	10
Metals/Natural Resources	38	14	17	12	1	18
Retail-General Merchandising	19	17	25	5	3	31
Retail-Specialty Merchandising	29	17	21	11	6	16
Telecommunications	33	14	18	18	4	13
Average	*32.62*	*15.90*	*20.10*	*14.67*	*3.57*	*13.14*

Note: (Date gleaned from IW500 Analytics Report, 2008)

The highest percentage of IT investments is allotted to IT employees' salaries and benefits followed by software, hardware, and IT services in descending order. The specific budgets allocated to Research and Development (R&D) is a mere 3% while systems maintenance and administration services take on an average close to 13% of the total IT investment budgets.

Firm Innovation

Innovation is an important firm strategy and innovative firms have been found to earn above normal profits (Lopez-Nicolas & Merono-Cerdan, 2011). For instance, in the 2009 annual study of the Global 1000 innovators, Booz & Company reported that even with the recession, most of the companies had maintained their innovation projects and that these firms were indeed boosting their innovation investment so as to be competitive in the upturn. According to Robert Lardon, Corporate Vice President for strategy and investor relations at Harman International Industries Inc. (Public, NYSE:HAR), "innovation is what drives our competitive position in all three of our markets - automotive, professional, and consumer and we cannot back off" (Jaruzelski & Deholf, 2009, p. 3). Elsewhere, in the 13th annual ranking of the best 50 firms by Business Week Magazine, *BusinessWeek50*, Foust (2009, p. 40) indicated that "innovation remains a powerful engine of success" for these firms.

Researchers have generally conceptualized innovation through the amount of money spent by firms in their R&D activities, the number of patents granted to the firm or applied for by the firm, the number of patent citations, new product announcements or introductions, etc. Raw patent counts have been extensively used to represent firm innovations, as they are considered to be a good indicator of the inventive performance of firms, reflecting new technologies, new processes, new services, and new products (Acs & Audretsch, 1989; Ahuja & Katila, 2004; Griliches, 1998; Maarten, Geert, & Jan, 2009; Shan et al., 1994).

For this study, a broad definition of innovation was adopted that included new and improved products, technological artifacts, processes, and services that were either physical in nature or were encapsulated in intangible forms such as key ideas (i.e., software) that have the potential to meet a user's needs and economic rents for the innovating firms and are represented by patents (Joshi et al., 2010). There is a plethora of research studies that have adopted patents as a measure of innovation (Griliches, 1998; Jaffee & Trajtenberg, 2002). A patent confers upon the inventor the sole right to make, use, and sell an invention for a specified period of time, usually 20 years. A patent details information about the specific innovation, the inventors, and the affiliations of the inventors. Thus, a patent clearly illustrates technological and scientific linkages that traverse generations of inventions as well as the knowledge flow across individuals, organizations, geographical regions, and countries (Jaffee & Trajtenberg, 2002).

Patent-based innovations are knowledge driven in that they involve applications and the generation of scientific, technical, and experiential knowledge. Patents are also unique in that they allow the investors/inventors to appropriate a larger portion of the profits accruing from innovations. Patents are the strongest form of legal protections against imitations by other firms (Teece, 1998).

In this research, the above researchers' conceptualization and measures of innovation were adopted resulting in the use of applied patents and granted patents (Freeman & Soete, 1997; Griliches, 1998). The innovation output of a firm is represented by a factor score that is generated (through factor analysis) after normalizing (log base 10) the raw count values of applied patents and granted patents. The factor score was created to eliminate the limitations of using one variable in the measurement of innovation output, namely the raw count values of either applied for or granted patents. Applied patents refer to those patents that firms have invested in but have not yet been approved by the United States Patent and Trademark Office (USPTO) while the granted patents refer to the patents which have been approved by the USPTO (Jaffe & Trajtenberg, 2002). Although this factor score only dealt with those innovations that had been patented (output), it was found that the factor score was highly correlated (0.87) with R&D investments, which were considered an input into the innovation process, thus providing a good indication of a firm's innovative behavior.

Firm and Industry Control Variables

The ability of a firm to innovate is likely to be affected by the firm strategy, firm resources capacity, organizational motivation, organizational goals, as well as the interaction of the firm and the external environment. Also, investments in IT resources are not exogenous but are influenced by the internal firm factors as well as the external market and environmental forces (Xue, Ray, & Sambamurthy, 2012). For instance, the strategy of the organization can be reflected in the way the firm allocates its resources namely the amounts allocated to the R&D initiatives, IT investments, or expansion into new markets through mergers and acquisitions. Also, the debt level of the organization and its growth potential are a reflection of the organizational goals and strategies and have the potential to impact firm innovation.

With regard to the firm environmental factors, the market position of the firm in relation to the competitors, the risk inherent in the environment and the product diversification strategy employed by the firm also affect innovations. Since there are several factors that are likely to influence the relationship between IT investments and innovation, the study incorporates a number of firm and industrial control factors. The firm level control variables are Marketing and Advertising (M&A) intensity, firm size, debt ratio/leverage, and firm growth. The environmental control variables include environmental uncertainty, related and unrelated diversification, market concentration ratio, and the role of IT in the firm industry. These variables have been shown to have an impact on how firms allocate their IT investments (Banker et al., 2011; Kobelsky et al., 2008).

M&A intensity is an indicator of the firm's marketing capability and represents the efforts geared towards marketing and informing the market about the firm's new and innovative products, services, or processes. Firm size is controlled because of the varied arguments about the role that organizational size plays in fostering innovation. Debt ratio, also known as leverage, is the amount that the firm owes the creditors in the course of financing the obligations to the customers and stakeholders. Firms carrying a higher debt obligation are perceived to be risky and the risk factor affects the relationship between firm IT investments and commitment to innovation. Firm growth is controlled because growth is associated with increases in resources that lead to higher market share and ultimately higher profit margins that can be ploughed back into innovation focused endeavors.

Environmental uncertainty exemplifies the degree of perceived volatility and rate of change of the environment external to the firm (Matthews & Scott, 1995; Milliken, 1987). Higher levels of uncertainty require that a firm undertake initiatives that are geared towards offsetting the uncertainty. Diversification measures the extent of a firm's operations in different industries within the same two digit Standard Industry Classification (SIC) codes (Chari, Devaraj, & David, 2008). Also, related diversification entails the exploitation of economies of scale through the sharing of both physical and human resources across related lines of business. Firms pursuing related diversification strategy will also be more effective in responding to the customer-based opportunities that spur more innovations.

Unrelated diversification measures the extent of a firm's operations in different two-digits SIC codes. Unrelated diversification is aimed at efficient allocation of capital and other resources in an internal market rather than in the inefficient public market exchanges (Dewan, Michael, & Min, 1998). Industry concentration ratio is an indicator of the relative size of the firm in relation to the industry with higher values being associated with market domination and monopolistic business structures. For instance, monopolists have been shown to innovate more rapidly in order to retain their market share and high profits in markets characterized by low or nonexistent barriers to entry. The industry in which a firm operates can be classified as either hi-tech or low-tech (Francis & Schipper, 1999). Hi-tech firms are thus expected to be savvier at using IT to plan, implement, control, and assess the performance of innovation strategies. Table 3 provides a summary of the research constructs used for the study, their operationalization, and sources of data.

Table 3: *Definitions of Research Constructs*

Construct	Definition	Data Source	References
IT investments	Annual firm IT investments scaled by sales	IW500	Kobelsky et al., 2008; Banker et al. 2011
Firm innovation	A factor score generated from applied and granted patents	NBER	Jaffe & Trajtenberg, 2002
Marketing & advertising intensity	Ratio of marketing and advertising costs scaled by sales	Compustat	Bharadwaj et al., 1999; Chari et al. 2008
Firm size	Size of the firm measured through market capitalization	Compustat	Fama & French 1993
Debt ratio/Leverage	Measure of what firm owes external stakeholders	Compustat	Kobelsky et al., 2008; Lang, Ofek, & Stulz, 1996
Firm growth	Realized growth of the firm based on sales	Compustat	Kobelsky et al., 2008
Environmental uncertainty	A measure of variability in the environment	Compustat	Kim, 2001; Kobelsky et al., 2008
Diversification (Related/Unrelated)	Extent to which a firm engages in more than one business venture or line of business	Compustat	Dewan, et al., 1998; Jacquemin & Berry, 1979; Palepu ,1985
Concentration ratio	A measure of firm power and industry competition based on the 4-digit SIC Codes	Compustat	Bharadwaj et al., 1999; Chari et al., 2008
Hi-Tech/Low-Tech	A value designating firms in high and low technology industries	Based on SIC Codes	Banker et al. 2011; Francis & Schipper, 1999; Kobelsky et al., 2008

Hi-tech firms have more sophisticated IT resources, which should offer these firms superior capabilities in gathering, analyzing, assimilating, and disseminating information and knowledge within and across firm boundaries leading to more innovative ideas, processes, and products.

Data Analysis and Results

The estimation of the research model used data from three sources: IT investments from *InformationWeek 500*, patents from the National Bureau of Economics Research (NBER), and control variables from Compustat as shown in Table 3. The data set was generated by merging IT investments, innovation, and control variables, which consisted of 69 global firms for a total of 483 observations for IT investments from 1991 to 1997 for innovation from 1991 to 1999, and for control variables from 1991 to 1997. Thus, it is a balanced panel data set.

Data Research Context

Following prior research (Banker et al., 2011; Ravichandran et al., 2009), IT investments data was gleaned from InformationWeek 500 industry magazine from 1991-1997. The selected firms were those that had accounting/finance data in the Compustat database. The required accounting/finance data enabled the computation of the values for the control variables. Using the Compustat database, each firm was matched with its corresponding SIC code, and a unique identifier known as a Global Company Key (GVKEY, a unique six-digit key assigned to each company in the Compustat database) was generated. This GVKEY was used to match the firms in the NBER Patent Data Project to generate firms that had both IT investments data and patents data. The final sample data set was generated by merging these three disparate data sets and consisted of 69 global firms for a total of 483 observations for IT investments and control variables from 1991 to 1997, and innovations data from 1991 to 1999. Thus, the final sample is a balanced panel data set.

Data Cleaning

Following the recommendations of Hair et al. (2002) and Belsley, Kuh, and Welsch (1980), a number of tests were conducted that aimed at cleaning the data as well as examining the violations of assumptions of multivariate regression analysis. To start with, a number of data transformation techniques were applied and the values were 'winsorised' at 5% and 95% levels to eliminate the influence of outliers, which have been shown to be associated with Type I and Type II errors besides skewing the reliability of the estimates (Osborne, 2001). The outliers were eliminated after a careful examination of Cook's D distance statistics, 'studentized' residuals, and DFFITS as suggested by Neter, Wasserman, and Kutner (1990). Secondly, in testing the violations of normality, an examination of the distribution of the variables was done and the results ascertained that the variables were, on average, normally distributed (skewness range: -0.85 to 0.73; kurtosis range -0.49 to 0.65). Also, the Kolomogorov-Smirnov test for normality, which indicated no deviations from normality, and the White's test (White, 1980) for heteroscedasticity that supported the constant variance assumptions were done.

Thirdly, in testing the presence or absence of multicollinearity, an examination of the Variance Inflation Factors (VIFs) and tolerance values was done and both VIFs and tolerance values were found to be well below the threshold value of 10 (highest value was 1.28) and above the 0.10 (lowest value was 0.72) values, respectively

(Neter et al., 1990). Finally, the correlation coefficients of the variables used in the regression analysis were evaluated and found to be low enough to signify lack of multicollinearity (rs<0.70), thus justifying simultaneous inclusion in the regression analysis equation models.

Summary Statistics

Table 4 provides the descriptive statistics for the study variables for the 483 firms in the sample with IT investments, innovation, and control variables over the 1991 to 1997 period.

Table 4: *Descriptive Statistics*

Research Variables	*Min*	*Max*	*Mean*	*SD*
Innovation	0.693	8.183	3.843	1.588
IT investments	0.001	0.075	0.024	0.013
M&A intensity	0.000	0.100	0.011	0.021
Firm size	6.524	12.392	9.184	1.196
Debt ratio	0.000	0.857	0.194	0.124
Firm growth	0.001	3.280	0.098	0.171
Environmental uncertainty	0.001	0.150	0.032	0.028
Related diversification	0.000	1.309	0.267	0.310
Unrelated diversification	0.000	1.824	0.498	0.452
Industry concentration	0.299	1.000	0.795	0.190
Hi-tech/Low-tech	0.000	1.000	0.450	0.498

N=483, All variables winsorized at 5% and 95%		
SD	=	Standard deviation
Innovation	=	A factor score based on applied and granted patents for firm i at time t
IT investments	=	IT investments scaled by sales as reported by firm i in year t
M&A Intensity	=	Marketing and Advertising expense scaled by sales
Firm size	=	Size of the firm represented by log market capitalization
Debt ratio	=	Debt ratio (data9/data6) at time t on Compustat database
Firm growth	=	Average growth from sales computed as a ratio of t-1 and t
Environmental Uncertainty (EU)	=	Level of industry uncertainty (standard deviation of industry earnings before extraordinary item during the previous 5 years scaled by sales) at time t
Related Diversification (RD)	=	related diversification based entropy measures (see appendix for computation) at time t
Unrelated Diversification (UD)	=	Unrelated diversification based on entropy measurers (see appendix for computation) at time t
Industry Concentration (IC)	=	Measure of industry concentration and competition
Hi-/Low-tech	=	Binary value of 1 represents firms in high technology industries

These values are in line with similar studies that used analogous measures and data variables (Bharadwaj, Bharadwaj, & Konsynski, 1999; Chari et al., 2008; Kobelsky et al., 2008). The firms in this sample were weighted toward large firms with mean market capitalization of $9.18 billion (1991-1997), and this value was shown in Table 4 as the log value with base 10 for the firm size variable. The values were comparable to the firms in the Standard and Poor's database of 500 firms. On average, the firms in the sample spent about 2.4% of their sales revenue on IT in the years 1991-1997.

Table 5 presents the correlation coefficients among the variables adopted for this study. The Spearman correlations were above the diagonal while the Pearson correlations were below the diagonal. As predicted, IT investment levels were positively and significantly related to innovation, while innovation was positively and significantly related to marketing and advertising intensity, firm size, firm growth, uncertainty, and related diversification.

Table 5: *Correlations of the Research Variables*

Correlations(Spearman's above the diagonal and Pearson's below the diagonal)												
	Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**
(1)	Innovation	**1**	0.36	0.18	0.40	-0.14	0.05	0.18	0.14	-0.21	0.01	0.15
(2)	IT Investments	0.30	**1**	0.02	0.28	-0.15	0.00	0.12	-0.13	-0.08	0.01	0.13
(3)	M&A Intensity	0.14	-0.06	**1**	0.34	-0.19	0.03	-0.16	-0.01	-0.16	-0.06	0.01
(4)	Firm size	0.40	0.25	0.33	**1**	-0.13	0.03	0.12	0.14	0.15	0.02	0.06
(5)	Debt ratio	-0.19	-0.13	-0.11	-0.18	**1**	-0.10	0.09	0.16	0.24	0.15	-0.02
(6)	Firm growth	0.07	0.12	0.04	0.04	-0.14	**1**	0.12	-0.13	-0.07	-0.11	0.05
(7)	EU	0.13	0.10	-0.12	0.15	0.04	0.02	**1**	-0.07	-0.04	-0.03	0.15
(8)	RD	0.14	-0.15	0.05	0.08	0.14	-0.11	-0.11	**1**	-0.11	0.233	0.01
(9)	UD	-0.24	-0.02	-0.07	0.11	0.20	-0.06	-0.02	0.01	**1**	0.16	-0.10
(10)	IC	-0.02	0.04	-0.06	0.08	0.20	-0.02	0.05	0.20	0.13	**1**	-0.03
(11)	Hi-tech	0.15	0.16	-0.11	0.06	0.001	0.07	0.15	0.08	-0.10	0.05	**1**
Values higher than 0.07 or lower than -0.07 are significant at the 0.1 level, values higher than 0.09 or lower than -0.09 are significant at the 0.05 level, values higher than 0.13 or lower than -0.13 are significant at the 0.01 level; (2-tailed), N=483												

Moreover, firms in high technology (hi-tech) industries showed a propensity to innovate based on the correlation results in Table 5. Also, as predicted, innovation was negatively and significantly related to debt ratio and unrelated diversification.

Empirical Model

This research made use of a balanced panel data set to examine the relationship between IT investments and innovation. The study adopted the following cross sectional time series model, $y_{it} = \alpha + X'_{it}\beta + (\mu_i + \omega_{it})$ which estimated variance components for groups and error, while assuming the same intercept and slopes. In this model, $(\mu_i + \omega_{it})$ was the error component and was not correlated to the independent variables. Also, in line with the assumptions of Ordinary Least Square (OLS), the intercept, α, was constant and the error variances vary across groups and times (Baltagi, 2005). On substituting the variables from the data into the regression equation, Equation 1 is as shown below.

$$\begin{aligned} Innov_{i,t+n} = {} & \delta_0 + \delta_1 ITBGT\_Sls_{i,t} + \delta_2 M\&A\ Intensity_{i,t} + \delta_3 Firm\_Size_{i,t} + \delta_4 Dbt\_Rto_{i,t} \\ & + \delta_5 Gwth\_Sls_{i,t} + \delta_6 IndUnctyi_{i,t} + \delta_7 RD_{i,t} + \delta_8 UD_{i,t} + \delta_9 Ind\_Conc_{i,t} + \delta_{10} Hi\_tech_{i,t} \\ & + \varphi_{i,t} \end{aligned} \tag{1}$$

Equation 1 represents the relationship between innovation and IT investments while controlling for both specific firm and environmental uncertainty variables whereby:

Innov $_{i,t+n}$	=	*Innovation score for firm i at year t+n where t=0,1,2, and n=1, 2, 3*
ITBGT_Sls $_t$	=	*IT investments scaled by sales as reported by firm i in year t*
M&A_Intensity $_t$	=	*Marketing and Advertising costs scaled by sales as reported by firm i in year t*
Firm_Size $_t$	=	*Size of firm measured by log market capitalization for firm i in year t*
Dbt_Rto $_t$	=	*Debt ratio of firm i in year t*
Gwth_Sls $_t$	=	*Firm growth from sales for t-1 and t for firm i*
IndUncty $_t$	=	*Level of environmental uncertainty (standard deviation of industry earnings before extraordinary items for previous 5 years scaled by sales) for firm i in year t*
RD $_t$	=	*Related diversification based on entropy measures (see appendix for computation) for firm i in year t*
UD $_t$	=	*Unrelated diversification based on entropy measurers (see appendix for computation) for firm i in year t*
Ind_Conc $_t$	=	*Measure of industry concentration and competition for firm i in year t*
Hi-tech $_t$	=	*Binary value of 1 represents firms in high technology industries and 0 otherwise in year t*
φ_{it},	=	*Independent and identically distributed error term with zero means*

Results

The results from the cross sectional regression analysis are presented in Table 6 on the next page.

Table 6: *Results of a Cross Sectional Regression Analysis*

Innov	Predicted Sign	Model 1	Model 2
Intercept		-1.03 (-1.70*)	-1.40 (2.13**)
M&A_Intensity	+	0.10 (0.03)	2.25 (0.72)
Firm_Size	+	0.53 (8.94***)	0.44 (7.39***)
Dbt_Rto	-	-1.23 (-2.28**)	-1.05 (-1.97**)
Gwth_Sls	+	0.31 (0.82)	0.18 (0.50)
IndUncty	+	4.39 (1.90*)	4.43 (1.96**)
RD	+	0.47 (2.26**)	0.69 (3.21***)
UD	-	-0.87 (-5.88***)	-0.82 (-5.66***)
Ind_Conc	+	0.37 (1.06)	0.15 (0.44)
Hi-tech	+	0.27 (2.11**)	0.18 (1.44)
ITBGT_Sls	+		24.29 (4.84***)
Adj. R-squared		0.26	0.30
Δ Adj. R-squared			0.04***
F Value		19.98***	23.40***

Unstandardized regression coefficients are reported and t-values are in parentheses ****. Significant at the 0.01 level, **. significant at the 0.05 level, *.significant at the 0.1 level (2-tailed), N=483*		
Innov	=	Innovation score firm i at year t+n where t=0,1,2, and n=1, 2, 3
ITBGT_Sls	=	IT investments scaled by sales as reported by firm i in year t
M&A Intensity	=	Marketing and advertising intensity scaled by sales
Firm_Size	=	Size of the firm represented by log market capitalization as a ratio of t-1 and t
Dbt_Rto	=	Debt ratio at time t
Gwth_Sls	=	Average growth from sales
IndUncty	=	Level of industry uncertainty (standard deviation of industry earnings before extraordinary items for previous 5 years scaled by sales) at time t
RD	=	Related diversification based on entropy measures (see text for computation) at time t
UD	=	Unrelated diversification based on entropy measurers (see text for computation) at time t.
Ind_Conc	=	Measure of industry concentration and competition
Hi-tech	=	Binary value representing high technology firms in year t, 1 for firms in hi-tech industries.

Findings and Discussions

A time-series cross sectional regression analysis was carried out to test the effect of IT investments on firm innovation while controlling for both firm and industry factors. As shown in Table 6, the variables statistically significantly predicted firm innovation, *($F(10,472)=23.40, p<0.005$)*. Specifically, IT investments were positively and significantly (beta=24.29, $p<0.001$) related to innovations with a change in adjusted R^2 equal to 4%. Thus, one unit of IT investments input led to 4 units in innovation outputs. For the control variables, firm size (beta=0.44, $p<0.001$), uncertainty (beta=4.43, $p<0.05$), and related diversification (beta=0.69, $p<0.01$) were positively and significantly related to innovation while debt ratio (beta=-1.05, $p<0.05$) and unrelated diversification (beta=-0.82, $p<0.001$) were negatively and significantly related to innovation. On the other hand, marketing and advertising intensity (beta=2.25, ns), firm growth (beta=0.18.50, ns), industry concentration ratio (beta=0.15, ns), and hi-tech (beta=0.18, ns) were positive, as predicted, but not statistically significant.

The support for the research hypothesis suggests that IT investments enable the firms to acquire the capability to test new ideas at faster speeds and at lower prices/ costs. This is especially true currently, where firms utilize the internet and other web 2.0 technologies to communicate with their customers and stakeholders in soliciting ideas and inputs on new products or processes. These exchanges, communications, and interactions are accomplished within short time periods, possibly within hours, reducing the cost and time of innovative initiatives. On the other hand, these IT-enabled capabilities make innovations, "the lifeblood of growth, more efficient and cheaper" (Brynjolfsson & Schrage, 2009, p.1). By soliciting customers' inputs and feedback during the innovation processes, firms generate innovative products and services that are tailored to the needs of the customers, guaranteeing wider acceptance during the diffusion stages and thus, higher economic rents.

IT investments are also used in facilitating and organizing the know-how about a firm's past projects, expertise, and routines. In addition, investments in IT resources can help in the coordination of knowledge among different people in the firm, as well as between R&D groups in a firm adopting related diversification strategy by offering collaborative capability. IT investments in the form of communication tools such as networks, email, virtual meetings, blogs, and the more recent relation-oriented tools such as wikis, blogs, and social networking resources can also facilitate collaboration and teamwork by reorganizing and recombining the organizational knowledge.

For the control variables, the relationship between M&A intensity and innovation was positive as predicted, but not statistically significant. Also, the relationship between firm size and innovation was found to be positive, although not statistically significant. Large firms tend to be associated with the advantages of superior resources and capabilities that these firms have acquired over time. Also, large firms are more innovative because they tend to have more financial slack, superior marketing skills, and R&D capabilities, as well as product and service development experience (Nord & Tucker, 1987; Zhu & Kraemer, 2005). Hence, large firms can cushion against potential losses associated with unsuccessful innovation project ventures. Some of the IT investments are utilized in acquiring and training IT human resources. Thus, the hiring of IT professionals and skilled workforce with superior technical and business knowledge places large firms at the vanguard of technological development (Ettlie, Bridges, & O'Keefe, 1984; Popadiuk & Choo, 2006).

The negative association between innovation and debt ratio may be explained by the perceived risk associated with innovation that affects the relationship between firm IT investments and commitment to innovation. Innovation involves a number of stages that include ideation, project selection, development, and commercialization and lower firm debt levels are important at each of these stages. Lower debt levels or lower values for leverage (more free cash flows) ensure uninterrupted IT investments in initial innovation initiatives as well as availability of funds during the product testing, launching, and the ultimate commercialization. Also, lower debt levels offer free cash flows that firms can use to expand their knowledge bases, through the hiring of savvy IT professionals, or acquiring IT tech venture firms (O'Brien, 2003). A firm that has a higher debt ratio may not have the required funds to sustain the necessary IT investment levels associated with innovation.

Though indicative results of the relationship between firm growth and innovation were obtained, the lack of significant statistical support might be explained by the fact that not all growth comes from innovation. For instance, top executives seeking prestige and immediate job rewards may grow their firms through mergers and acquisitions (Matsusaka, 1993). Also, firms can grow their sales through competitive attacks such as steep price reductions or other aggressive sales campaigns. Although controlled growth brings with it economies of scale that are conducive to innovation, rapid growth can lead to rapid asset acquisitions, which result in tying-up resources that could be used for other ventures such as IT driven innovations.

The positive and significant relationship between uncertainty and innovation alludes to the fact that higher levels of uncertainty demand greater efforts in coordination and control at the firm level. As such, firms will resort to innovative endeavors – in products, processes or services – which lower the uncertainty levels. For instance, uncertainty requires more complex IT-enabled information processing systems and marketplace volatility is associated with the building of an extensive IT infrastructure (Broadbent et al., 1996). An extensive IT infrastructure such as Enterprise Resource Planning (ERP) or Supply Chain Management (SCM) links the various facets of the organization while also establishing and facilitating timely information gathering and sharing. Thus, firms operating in uncertain environments tend to be more innovative so as to overcome the inherent risks while also staying competitive.

A diversified firm seeks to limit market and operational risks based on the premise that not all products or service offerings move up or down the market simultaneously, allowing for a more consistent performance under various organizational and economic conditions. A firm engaged in related diversification, characterized by similar lines of business, is capable of exploiting economies of scope by sharing physical and human resources. As a result, a consistent revenue stream may be reinvested toward innovation initiatives. Moreover, a firm operating in a number of related business segments may exploit its core capabilities, resulting in economies of scale and scope, efficiency in allocating resources, as well as management synergy through the transfer of technical and management skills across the product or service lines (Rumelt, 1982). The core capabilities resulting from resource sharing and efficient allocation of resources may possibly lead to the positive relationship between related diversification and innovation.

Contrary to expectations, a significant relationship between the concentration ratio and innovation was not found. This was surprising as it was expected that firms in more concentrated industries would be more competitive and hence more innovative to mitigate the effects of market competition. The reason for the lack of significant relationship could be the heterogeneity of the sample space, which was comprised of firms from multiple industries, making it difficult to discern the effect of individual industries. Also, contrary to expectations, a significant relationship between hi-tech firms and innovation was not found. This could be because hi-tech firms are not very adept at using IT for innovation. Hi-tech firms use IT for streamlining and coordinating their business processes.

There is limited empirical research that examines the link between IT investments and innovation. Thus, this research contributed to this line of research by offering results that shed more light on the importance of IT investments in fostering firm innovations. This paper argued that IT investments enable a firm to reconfigure and recombine knowledge from various diverse sources to promote innovation and also facilitate the organizing of know-how about past projects, expertise, and routines.

Robustness of the Results

As alluded to earlier, the innovation score was computed based on the number of patents applied for and granted to the firm through factor analysis. Assuming that the effects of IT investments take, on average, 3 years to assimilate and yield noticeable business process improvements (Dewan et al., 1998), IT investments were related in year t to applied patents in year $t+n$ $(t=1,2,3,\ n=0,1,2,3,4)$, such that IT investments in 1991 were related to patents applied for in 1993. Also, since it takes around 3 years for patents to be approved by the USPTO, the patents applied for in 1993 were typically granted in 1995. Thus, the innovation score associated with IT investments in 1991 was generated from patents that were applied for in 1993 and granted in 1996, based on a 3-year sliding window. To examine the robustness of the results, a 1-year, a 2-year, and a 4-year sliding window were also used, and with the exception of the 1-year sliding window, the results of the cross sectional regression based on the model in Equation 1 were not significantly different. The only results presented were based on the 3-year sliding window to conform with the theory and also for space limitations. Alternative measures and specifications for other variables were also utilized. For instance, the study tested the model in Equation 1 using IT investments scaled by employees rather than sales. The results were not statistically different.

Research Contributions

This study contributes to the literature on the role of IT investments in creating business value through firm innovations in a number of ways. First, researchers have long been motivated by the economic significance of IT investments in studies examining IT business value (Loveman, 1994; Tallon, 2010), but the mechanisms or business processes that yield this value have been understudied. This study brings a closer understanding of this phenomenon by investigating the effects of IT investments on firm innovation, which can lead to business value. This study developed a theoretical framework for IT investment payoff in the context of innovation by specifically aligning the attributes of the KBV theory to the innovation life cycle. The adopted research framework drew from the literature on coordination and control in order to explain payoffs from IT investment in innovation. In this study, the question of whether an IT investment pays-off in the context of innovation was considered to be very significant from an economical perspective. Moreover, the motivation to consider the relationship between IT investments and innovation provides researchers with a firm basis that IT indirectly may yield business value through the commercialization of innovations.

Economists and management scholars agree on the role of innovations in generating economic rents at the firm, industry, or economy level. Firms that are persistent innovators have been demonstrated to appropriate superior economics rents compared to their competitors (Anthony, Johnson, & Sinfield, 2008). In this respect, IT investments played a key role by spurring innovation in the firms that ultimately lead to business advantages. Also, by systematically investigating the relationship between IT investments and innovation, this research was differentiated from prior research studies, which focused on the direct link between IT investments and business performance. As such, this research offered an explanation for the seemingly conflicting findings about the impact of IT on business performance in the extant literature. The results of a positive relationship between IT investments and innovation added credence to the notion that the impact of IT investments should be carried out at the business process level, where its first order effects are more often realized. This study narrowed that gap by linking IT investments to innovation, which is a key driver of superior business performance.

Limitations

The IT investments data adopted for this study were not based on the actual IT resources specifically allocated to the innovation processes, but were an aggregate value of all the IT investments utilized by the firm. Future studies should try and address this shortcoming. A fine-grained analysis of actual IT investments data dedicated to the firm innovation processes might provide a better understanding of the roles of IT investments in fostering the firm innovation. Also, the sample frame was not randomly selected and was based on a data set comprising firms that appeared in the *InformationWeek 500* and for the most part these firms self-reported their IT investments data. As such, the generalizability of these results to other firms is open to scrutiny.

Another limitation of this study was the use of *InformationWeek 500* dataset. Although the dataset had been used extensively in previous studies (Kobelsky et al., 2008; Banker et al., 2011; Im et al., 2013), it may be considered dated. However, studies that used duration are better suited to "old" data due to their longitudinal nature that require a couple of years between the investments and the results (Dehning & Stratopoulos, 2003). Future studies should use more recent data to replicate and confirm that the findings still hold after a decade of rapid and widespread use of IT.

The use of patents as a measure of innovation may pose some limitations too. Nevertheless, there is a longstanding debate on the use of raw-patent counts as a measure of innovation output at the firm, industry or economy level (Griliches, 1998). Some critics have argued that patents should be differentiated by value. That is, weights should be assigned based on the economic value of the patent. However, researchers in management and economics have generally accepted raw-patent counts as one indicator of the innovative performance of firms as depicted by new processes, new technologies, and new products. Future studies should seek to use survey data to gather more data on new products and services introduced by firms and the portion of IT investments allocated to each innovation process.

Conclusions

IT has permeated many facets of organizations and is being utilized, for instance, to internally coordinate, control, and facilitate organizational processes and management decision-making processes. Externally, firms have made IT investments that enable and facilitate interactions with customers, suppliers, and other stakeholders as demonstrated in the use of CRM, SCM, or ERP systems respectively. These are organizational day-to-day business oriented processes, which result from IT investments and in one way or another have a direct or indirect impact on firm innovation. For example, an effective and efficient IT-enabled value chain is an indispensable firm asset that facilitates the generation and capture of ideas on new products, or processes designs, improvements on existing products, and processes as well as retirement of non-rent generating products, services, or business processes. Capturing and understanding valuable knowledge is a firm capability, because these ideas will ultimately be converted into innovative products or services. These ideas also offer a firm several opportunities to identify its strengths and weaknesses. The benefits accruing from innovations are amplified when a firm integrates and aligns its business strategy with IT investment initiatives.

Resources attributed to IT investments have transformed the processes through which firms engage in innovative endeavors (Brynjolfsson & Schrage, 2009). For instance, firms rely on employees, customers, suppliers, and other stakeholders for breakthrough ideas on products, processes, or service innovations. New ideas are generated, shared, and developed through collaborative trial-and-error initiatives by different entities that supersede the Schumpeterian model of lone entrepreneurs (Schumpeter, 1987). Thus, by investing in IT resources, firms can make use of industry value chains that connect the firm with customers, suppliers and other trading partners encapsulating diverse pools of knowledge across the firm, which is an indispensable resource for innovation.

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Appendix

Diversification

In measuring business diversification, this study utilized information from Compustat database business segments (Rule 14 of the FASB mandates public firms to disclose information on significant business segments, and a significant business segment is one that accounts for more than 10% of the total firm assets, sales, or profits). The two dimensions of diversification namely, related and unrelated diversifications were computed as shown in the equation below following Jacquemin and Berry (1979), and Palepu (1985).

Figure 2: *Equations for Computing Related and Unrelated Diversification Values*

Related Diversification = $\sum_{J=1}^{M} \sum_{l=1}^{N_J} S_l^J \ln \frac{S^J}{S_l^J}$	Unrelated Diversification = $\sum_{J=1}^{M} S^J \ln \frac{1}{S^J}$

N is the number 4 – digit SIC industries a firm is active in, indexed by i,
which in turn aggregate into M2 – digit industry groups, indexed by j, ($M \leq N$),
N_J is the number of different industries in group j,
S_i is the share of industry i in total firm sales,
S^J is the share of group j in total firm sales,
S^J_i is the share of firm sales in industry i of firm sales in industry group j

Table 6: *Diversification Values as Computed from Total Sales for Selected Firms with IT Budgets in 1996*

			Group 1		Group 2		Group 3	Group 4				
Company Name	GVKEY	Total Sales	SEG 1	SEG 2	SEG 1	SEG 2	SEG 1	SEG 1	UD	TD	RD	# of SEGs
Baxter Int. Inc	2086	5438	5438						0.000	0.000	0.000	1
Bemis Co. Inc.	2154	1655	1180	474					0.000	0.599	0.599	2
Chevron Corp.	2991	37580	3422		33832				0.313	0.313	0.000	2
Crane Co.	3580	1865	207		363		246	734	1.197	1.197	0.000	4
Intl Paper Co.	6104	21400	2665	3475	5640	494500	4675		0.707	1.577	0.870	5

SEG = business segment