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INNOVATION VALUE OF INFORMATION TECHNOLOGY: IMPACT OF INFORMATION TECHNOLOGY – INTENSITY ON INNOVATION CAPABILITY AND FIRM PERFORMANCE

By

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ABSTRACT

INNOVATION VALUE OF INFORMATION TECHNOLOGY: IMPACT OF INFORMATION TECHNOLOGY – INTENSITY ON INNOVATION CAPABILITY AND FIRM PERFORMANCE

By

Mahesh Kumar Ramamani

Though information technology adoptions have been always referred to as innovations in firms, much of the business value literature has concentrated on the tangible and immediately measurable impacts of information technology (IT) adoptions. This study aims to explore the impact of information technology investments on the innovativeness of a firm. We assess the impact of information technology as a complement to the commitment shown by firms towards innovation. We explain that the organizational commitments to innovation are of three different types – financial, managerial and temporal. We show how the availability of information technologies may help the firm leverage tangible value from the various types of commitments that it has made to innovation. Most studies in innovation are in the context of either product or process based innovations. In this study, we consider the firm as a platform where both process and product innovations happen concomitantly and consider hence capabilities of a firm that are related both types of innovation together.

The results of our analyses confirm and validate the vital role played by information technology investments of a firm on its innovation characteristics and behavior. Not only does the IT intensity of a firm complement the various types of commitments that a firm makes towards innovation but also plays a significant role in changing the

innovation behavior of the firm. The research has both academic and managerial implications. Academically, it tries to complement both the marketing literature and information systems literature. It attempts to complement the business value of IT literature by explaining the innovation value of IT investments. At the same time, it also tries to position IT Intensity of a firm as a key antecedent to innovation in firms in the new product development literature. The study also clarifies to the manager the conditions that facilitate and lead to effective innovations within the firm both at the process and at the product level. It also provides appropriate guidance on successful innovation strategies for the firm based on the industry it belongs to.

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CHAPTER 1: INTRODUCTION

Information technologies (IT) have had a significant impact on organizations in a number of different ways. Researchers have studied the impacts of IT on different dimensions of business and have established IT as a strategic factor in organizations. To begin with, researchers have found IT to directly impact the operational aspects of the firm that enables the firm to be more efficient (Mukhopadhyay, Kekre and Kalathur 1995, Menon and Lee 2000), reduce errors overall (Mukhopadhyay, Rajiv and Srinivasan 1997) and enhance the quality of business process execution (Devaraj and Kohli 2003). As firms have grown increasingly dependent on IT, research has also found how IT has impacted organizational and strategic aspects of a firm. For example, IT has been shown to improve customer satisfaction (Devaraj and Kohli 2000), enhance organizational learning and memory (Alavi and Leidner 2001, Robey, Boudreau and Rose 2000) and provide strategic benefits that lead to competitive advantage of firms (Ray, Barney and Muhanna 2004). While the literature on the business value of IT has been consistent in finding that IT has had a positive impact on organizations at all levels – on economic aspects, on operational aspects and on other organizational aspects, there is limited understanding of the role of IT in the innovation process of the firm.

Innovation in organizations occurs at different levels. While some innovations may be oriented towards introduction of new and enhance products and services, some may be oriented towards improving efficiency of manufacturing or the efficiency of providing customer support. IT has been used by firms in both new product oriented innovations and towards innovations oriented enhancing the firm's business processes.

Technologies like Enterprise Resource Planning (ERP) have helped firms gain control of their business processes and streamline the same causing huge operational improvements (Cotteleer and Bendoly 2006). And technologies like groupware and knowledge management systems have been used by firms to enhance their product designing and development activities (Kane and Alavi 2007). The fundamental nature of the role of IT in the innovation process of the firm has been alluded to by some researchers. For example, Sambamurthy et al (2003) explain IT as a factor that provides firms with digital options that are enacted on by entrepreneurial capabilities within the firm and Wheeler (2002) explains how the Internet and e-business provides a chance for a firm to adapt changes in its core business processes and on the basic nature of its products and services. However, some other studies have argued that IT in organizations institutes new routines that may be more rigid and loss of idiosyncratic processes because of enhanced control and central governance (Vaast and Levina 2006). IT has also been explained as a factor that may also bring about tight coupling between organizational units that may be inflexible and unable to adapt to change with the needs of the business appropriately (Sahaym and Steensma 2007). Hence, there is a lack of clarity on the role that IT plays in the innovation process of the firm and the circumstances in which it may enable or cripple innovation. Hence, it is important to resolve this through an investigation of the impact of IT on many different aspects of innovation in a firm which we attempt to do in this research.

The process of innovation has been explained by many as chaotic and one that is difficult to be structured and controlled and as involving serendipitous discoveries (Garcia and Calantone 2002). Most of the studies that have examined the value of IT

have been embedded in a specific context like the postal department mail sorting facility (Mukhopadhyay et al 1997) or the healthcare context (Devaraj and Kohli 2003). These studies demonstrate how IT has been deployed in different contexts in a very purposive manner and the nature of its operational impact on the business process. However, IT also has enabled serendipitous and extemporaneous innovations in firms. For example, General Motors (GM) introduced a new service that is enabled by the Global Positioning Systems (GPS) technology in 1997 called OnStar. The aim of the service was to provide road side assistance to driver of the car during the life time of the vehicle. This service was launched with a view to enabling a steady relationship with the customer after the sale of the car and to have revenue generation based on the relationship. The OnStar service provided a new revenue stream to GM based on monthly subscriptions which was a significant departure from the business model of GM at the time. OnStar reported revenue of about US$ 3 Billion from over 5 Million subscribers in 2008. This innovation by GM was motivated by the willingness of the firm to develop a closer relationship with its customers enabling it to track their actions much more closely. In this context, IT had enabled innovation by acting as an agent of unintended change. Such a role of IT as an agent of change in unstructured processes of the firm like innovation is less studied. The information systems literature on business value of IT has not paid attention to such unstructured processes of a firm through which a firm may innovate. This research seeks to address this aspect of IT and aims to study the impact of IT specifically on the innovation characteristics and innovation behavior of a firm.

Innovation in firms may be oriented towards either introducing new products or improving the efficiency of business processes. The marketing literature has laid a lot of emphasis in the study of innovation in organizations and as particularly concentrated on different aspects of new product development. They have explained how product based innovations can be either radical and disruptive or incremental and compatible in nature (Song and Montoya-Weiss 1998, Veryzer 1998). However, improving the efficiency of the production processes of a firm also has been a primary focus area in the management literature. This focus on structuring the processes of production hence is very commonly seen in manufacturing processes of a firm like the assembly line, sorting and grouping of material, warehouse stocking and so on. However, more recently such focus on managing processes has shifted from merely the manufacturing processes of a firm to administrative processes, product development processes, distribution processes and many other business processes of the firm (Garvin 1998, Cole 1998). While we investigate the role of IT in the innovation process of a firm, it is important that we distinguish between the nature of innovation based on whether it is process oriented or product oriented. This is because, the same technology can be put to use by different firms in many different ways. For example, while the Internet and the digitization of music has led to fundamentally different set of products in the music industry (songs as compared to albums), the Internet has also been used by many firms to restructure their customer interaction processes in a way that it is more cost effective for the firm (Wheeler 2002).

The Resource – Based View of the firm (Penrose 1959, Barney 1986) has influenced a lot of extant research on the business value of IT. Earlier, IT was treated as

a resource that created significant differences between firms. However, more recently the researchers have shifted focus towards capabilities. IT is viewed as an artifact that enables the development of strategic capabilities, its competitive response and its ability to effect desirable changes at the operational as well as at the enterprise level (Sambamurthy, Bharadwaj and Grover 2003). The root of this research lies at the ability of a firm to appropriate development of strategic capabilities from their IT deployment. Researchers have accordingly deployed theories of knowledge – based view of the firm to guide their research in this area. The knowledge-based view of the firm emphasizes the ability of organizations to create cross-functional and inter-firm capabilities helps in knowledge integration (Grant 1996). The research primarily argues that a high level of IS integration across firms forms the basis of development of critical organizational capabilities by enabling re-combination of knowledge from different parts of the organization and also from the various interfaces of the organization with the environment. Following this, we also view IT enablement in an organization as an organizational resource that fosters integration of knowledge and information at different levels of the firm and accordingly help us investigate the consequent impact of IT on the firm's process innovation and product innovation. Specifically, the research questions that would be addressed by this dissertation are:

a) How do investments in information technology enable the development of innovation capabilities of a firm?

b) How do investments in information technology affect the development of process and product innovation in firms?

The process of innovation in a firm has been one of significant emphasis in the marketing literature. The new product innovation literature in the marketing discipline was primarily motivated by addressing the factors that lead to successful products or successful innovations in a firm. Their literature looks at innovation as a process by which a firm brings to market new or improved products and services (Garcia and Calantone 2002). Though this stream of studies do not show an explicit emphasis on information technology aspects of a firm in the innovation process of a firm, it is important to address the innovation process in the context of the business value of IT literature to ably analyze the research questions raised above. It is important to understand what capabilities enable a firm to successfully manage its innovation efforts directed at improving their production processes. It is also important to understand the capabilities that enable a firm to successfully manage the technological innovations within the firm aimed at creating new products and services. The main focus of this research is to study how such capabilities are facilitated or curtailed by the firm's IT.

The impact of IT on knowledge creation within the firm, enhancing the absorptive capacity across the firm, improving information sharing and aiding development of shared understanding between several collaborating units within and without the firm is well documented (Malhotra, Gosain and El Sawy 2005, Zahra and George 2002 for example). The impacts of IT on these organizational aspects of the firm were studied in a specific context and based on specific IT applications. So also were the studies that studied operational improvements in the functioning of a firm due to IT (Mukhopadhyay et al 1997). However, in a study that aims to address both the operational level impacts and the organizational impacts of the firm, the impact needs to

be studied from a higher level perspective thereby addressing capabilities that enable process innovations and the capabilities that enable product innovations.

In the next chapter, a review of the literature that guides this research is presented. The literature streams addressed by review are – economic value of IT, business value of IT, organizational capabilities that complement the IT capabilities of the firm and finally the literature on technological innovations and new product innovation from the marketing disciple. The review is aimed at not only presenting a synthesis of studies that address the research phenomenon in question but also to help guide development of a framework that would help study the research questions raised above. In chapter 3, the theoretical framework that helps analyze the research question is presented and explained followed by a description of the research methodology to empirically test the hypotheses raised in chapter 3 in chapter 4. In chapter 5, the results from the empirical analysis is explained followed by chapter 6 that discusses the results and findings from the research addressing the academic and managerial implications of the same.

CHAPTER 2: LITERATURE SYNTHESIS

The business value of IT has remained an area of significant interest in the information systems literature. The stream of studies on business value of IT initially concentrated on establishing whether investments in IT have any economic impact of the firm. A number of studies have established the nature of economic impact that IT has on an organization. The attention has shifted in the literature towards explaining how firms exploit and capture value from IT. In this pursuit, scholars have studied the impact of IT on several organizational aspects and in several contexts. In the section, we present a synthesis of the business value of IT literature with a view to drawing from the extant literature to build the foundations for this study.

Economic Value of IT

The initial studies on the business value of IT concentrated on establishing whether the IT investments made by the firms have any economic impact on them. It started mainly in the late 1980's when economists found little or no evidence of productivity growth in the industries or firms even after significant investments in information technologies. This "productivity paradox" was particularly interesting because despite astonishing improvements in the underlying capabilities of computing, economic value from IT investments were non-traceable (Roach 1987 and Solow 1988). This paradox was resolved by research studies that proved using rigorously collected data from the industry that investment in IT does lead to significant productivity gains (Brynjolfsson and Hitt 1995, 1996 and Lichtenberg 1995). Following this, researchers

have considered the relationship between IT investment and business value from various perspectives, such as sustained advantage (Bharadwaj 2000; Clemons 1986; Clemons & Row 1991; Mata, Fuerst, & Barney 1995; Ross, Beath, & Goodhue 1996), strategic alignment (Chan, Huff, Barclay, & Copeland, 1997; Venkatraman, 1994; Henderson, Venkatraman, & Oldach, 1996), and infrastructure capability (Weill & Broadbent, 1998; Weill & Vitale, 1999). In most of the early studies, IT investment was mainly measured by the investments made by a firm on computer and related hardware. In most studies, investment is defined as an annualized value of the stock of computer investments including the depreciated value of previous investments that are still in service, or as annual spending. The basic assumption in most of the studies was that he investments in IT are meant to mainly assist the employees in carrying out their operations and correspondingly, employee productivity was commonly studied and IT investments were treated as an additional input factor in the production process of the firm.

In the research that followed on IT value, Hitt and Brynjolfsson (1996) explained that the gains in productivity registered by firms does not translate into profitability in all cases and that it is dependent on complementary organizational inputs like best practices and special capabilities. Also, in order to gain greater understanding of how IT impacted managerial processes and functions, it was important that researchers studied the impact of IT investments at intermediary levels (Mukhopadhyay et al 1997) like for example, processes, business units, functions etc. The economic analyses assumed IT as a sheer input factor in the production process of the firm was too coarse and did not offer such deeper understanding of the role of IT within a firm.

In order to understand the overall impact of IT at the firm level, it is useful to begin by thinking about the qualitative impacts of introducing IT into a firm's production processes. Past research has distinguished between using IT to automate processes, to provide better information across all levels of the firm and to transform entire processes (Zuboff 1988). Initial assumptions by economists were that automation provided by IT was a substitute for capital (Strassmann 1990). However, the capabilities provided by IT far exceed such a simplistic explanation. One key difference between IT capital and other forms of capital is the dual roles that IT can play in a firm. First, like other types of capital, IT can be used directly as a production technology to improve labor productivity and second, as a technology for coordination (Bresnahan, Brynjolfsson and Hitt 2002; Gurbaxani and Whang 1991; Malone et al. 1989) of production. It is this special nature of IT investments that makes IT to be more than just capital support to enhance productivity. IT impacts by not only its ability to improve productivity but also enhance quality of operation by providing superior information inputs. Thus, IT capital leads to a growth in the multi – factor productivity (Lichtenberg 1995). As the overall evidence on the economic payoff from IT investments became clearer, there was a growing interest in finding out what conditions cause superior pay offs from IT and how firms employ their IT to extract benefits from them and why some firms are good at employing IT while some are not. In the next section, we look at this aspect of the business value literature.

Organizational Impacts of IT

With the establishment of the economic value of IT investments, research on how firms deploy their IT assets and when they extract value from their IT investments gained significant focus. The literature started addressing the impact of IT on not just economic outcomes of firm but also other organizational measures like customer satisfaction, process efficiency and process quality. Also, while there were some studies that showed positive impact of IT on a firm's financial accounting measures, a number of studies also were inconclusive on whether IT investments affected a firm's accounting performance measures. Despite evidence from Bharadwaj, Bharadwaj and Konsynski (1999), where the IT expenditure of firms was shown to positively affect the firm's long run benefit and hence reflected in the market evaluation of the firm's value in the form of Tobin's Q ratio, there have been a number of studies that have been inconclusive on whether IT investments directly affect a firm's financial or accounting performance (Soh and Markus 1995, Wade and Hulland 2004). The fact that a firm's financial performance is determined by a wider range of strategic and competitive factors and the lack of consensus on the IT impacts on the same led to a search for investigating the impact of IT on firm performance measures like inventory turnover, plant productivity, and product quality.

This gave rise to a large number of studies that examined the impacts of IT investments on specific organizational variables. Several studies show a relationship between IT investment and intermediate measures of operational performance. For example Barua, Kriebel and Mukhopadhyay (1995) found that IT investments significantly reduced inventory turnover but this increase in operational efficiency did

not translate to firm performance. Investments in electronic data interchange (EDI) were found in a similar study to reduce shipment discrepancies thereby reducing wastage in general (Srinivasan, Kekre and Mukhopadhyay 1994) and materials management using ERP technologies helped firms reduce cost of holding inventory and transportation. Mukhopadhyay et al (1995) in their study found that using specific information technologies in mail sorting processes recorded not only great improvements in the sorting quantity but also significantly reduced errors thereby enhancing the quality of the process as well. Scholars have also studied the impacts of IT investments on certain specific functional outcomes like customer satisfaction. For example, Devaraj and Kohli (2003) found that IT investments in healthcare lead to substantial improvements in the healthcare quality leading to better cure that translated into effective increases in patient satisfaction. The aim of this research is to add to this tack on the literary course where we analyze the impact of IT investments on organizational innovation related variables and outcomes.

IT Capability View

The resource – based view (RBV) of the firm assumes that a firm is endowed with valuable resources that provide it with a competitive advantage and hence provide value (Barney 1996, Wernerfelt 1984). Barney (1996) explains that such resources should be valuable, rare, inimitable and non-substitutable. Information systems researchers have applied the resource – based view to suggest that some firms view IT assets as key resources and exploit it to leverage competitive advantage. Strategic management distinguishes between resource - picking and employing them to develop capabilities.

Resource picking is about identification and acquisition of valuable resources and capability building is about designing and constructing organizational systems to derive value from the resources that the firm owns. Firms also combine different types of resources that are amenable to them to create higher order resources or capabilities that may give competitive advantage for the firm (Grant 1996). Capabilities are defined as a firm's capacity to deploy resources in combination with other resources using organizational processes (Amit and Shoemaker 1993). Since capabilities are based on the organizational processes of a firm, they are firm – specific and are developed over a period of time. However, over a period of time the firm is forced to experience a change in its environmental conditions and situations that allow it to have a competitive advantage. Hence, the notion of dynamic capabilities was proposed to explain a firm's ability to keep modifying its organizational processes in such a way that it shifts the nature of capabilities it builds using the resources it possesses (Nelson and Winter 1982, Teece, Pisano and Shuen 1997). Dynamic capabilities framework suggests that when firms face turbulent situations due to technology changes, market uncertainty etc, honing internal technological, organizational and managerial processes provide a firm with a chance to adjust the capabilities that it builds from the resources that it has at disposal. Firms that have leveraged key advantages through IT not only acquired the IT assets but also deployed them effectively. Hence, such firms were said to possess key IT capabilities developed through a synergistic combination of IT assets with organizational routines and processes and other valuable resources owned by the firm.

Bharadwaj (2000) defined IT capability as the ability of a firm to mobilize and deploy IT – based resources in combination with other resources and capabilities such

that it yields greater benefits for the firm. A closer look at the IT capabilities as has been studied in the literature reveals that it includes activities that pertain to management of IT such as - system design and software development, management of outsourced software development projects, planning of information assets, managing system implementation projects, and management of portfolio of IT assets (Boynton and Zmud 1984; Feeny and Wilcocks 1998; Levina and Ross 2003; Ross, Rockart and Earl 1996). Moving further from linking IT resources to firm performance, this helped appreciate the importance of how the IT resources are deployed by firms in a beneficial way. It was found that firms with higher levels of IT capability outperform firms with lower levels of IT capability over both cost and profit related measures (Bharadwaj 2000). Further studies helped understand in greater detail on the constituents of IT capabilities. Feeny and Wilcocks (1998) identified nine core aspects of IT capability of firm based on field inputs - IS/IT leadership, business systems thinking, relationship building, architecture planning, making technology work, informed buying, contract facilitation, contract monitoring, and vendor development. It is interesting to note that these aspects stretch across three dimensions – the business view, the technology view and the design and delivery of IT. It was in line with the theoretical conceptualization of IT capability as a higher order construct that is based on certain specific IT aspects of a firm's strategy - IT business partnerships, external IT linkages, business IT strategic thinking, IT business process integration, IT Management, and IT Infrastructure. These different aspects of IT capabilities have been summarized in Table 1 along with the research studies that have reaffirmed the same. How do these IT capabilities impact the firm in its operational aspects and what factors enable it? Some of the contemporary research

empirically studied specific IT capabilities and their impact on some specific measures of a part of the production process.

Table 1: Core IT Capabilities

Research Study	IT Capability	Description
Boynton, Zmud and Jacobs (1991)	IT – Business Integration	Integration of IT effort with business priorities. Involvement of business managers in IT issues.
Broadbent, Weill and St. Clair (1999)	Process Mindset	Cognizant usage of IT in each business activity.
Ross et al (1996), Roepke, Agarwal and Ferrat (2000)	Technological Competency	Creation technology platform for business – Design and development of information systems.
Boynton and Zmud (1984)	IT Management	Organization of IT function to suit the business need of the firm
Lacity and Willcocks (1998)	IT Sourcing Competency	Knowledge and analysis of IT products and services market.
Lacity and Willcocks (1998)	Outsourcing Management	Management and execution of contracts with external IT vendors.
Levina and Ross (2003)	Vendor Partnerships	Identification of capability of IT vendors and building partnership to leverage them.

Clark, Cavanaugh, Brown and Sambamurthy (1997) found that at Bell Atlantic, the change ready capabilities enabled the firm to deliver IT – based products and services at shorter development cycle times. They also found that the firm was able to effect this innovation in their development process due to the complementary organizational adjustments like – design of organizational structure to enable the process change, grouping people according to their roles, relationships and incentives.

While studying the impact of IT on innovation characteristics, we understand that IT capabilities of a firm may impact how firms innovate on their processes and products and that IT resources and their deployment should be central to the theoretical framework. However, as we saw above, it is also important to appreciate the nature of complementary organizational inputs that enable firms to leverage benefits from IT capabilities. We will look at the literature on complementary organizational capabilities in the following section.

The literature also explains how IT resources and capabilities have helped firms develop other strategic capabilities. Some of the early studies that linked IT assets to strategic capabilities pertained to an era where proprietary information technologies were common and IT capabilities varied hugely based on the IT assets of the firm. Due to their rare, inimitable, non-substitutable, and valuable characteristics information systems as American Airline's SABRE, (Cash and Konsynski 1985; Hopper 1990) and American Hospital Supply's ASAP (Vitale 1990) by themselves were sources of superior competitive advantage. However with ubiquitous nature of the information systems the IT resources are no more rare, inimitable, or non-substitutable. Researchers have thus highlighted the need to focus on the capabilities perspectives to study assimilation in the organizational processes of IT in combination with complementary resources and through idiosyncratic paths (Clemons and Row 1991).

To take a historical look at how organizational capabilities have been studied, one of the first frameworks used by researchers on firm capabilities was that of organizational value – chains. Porter and Miller (1985) gave the guidelines for applying the value chain perspective to development of strategic capabilities from the

information systems by adding value to the firms' value chain offerings. The value chain framework has been employed by researchers to study how capabilities in firms led to effective innovations by firms. For example Lindsey, Cheney, Kasper and Ives (1990) empirically studied the role of TELCOT system at Plains Cotton Cooperative Association (PCCA) to strategically enhance the value of firm's offerings. The system helped PCCA to replace the phone as a means to seek bids fort its cotton. The electronic market so established helped move PCCA from being a merchant to a broker. The increase of information content to its products helped it to move up the value chain and offered a great strategic capability to PCCA. Thus, we understand from the literature that there are two types of IT impacts from a capability view. One is the impact of a firm's IT capabilities at the firm's business process level and the second is the impact of IT capabilities at an organizational level. In the next section, we would look at the literature on what complementary inputs enable development of strategic firm capabilities and their impacts on the firm.

Organizational Capabilities

Clemons and Row (1991), built on Teece's (1986) work on the economics of innovation defined the creation of these strategic capabilities through combination with the complementary resources. Though IT should lower the cost of vertical and horizontal firm transactions, the effect occurs only in combination with the complementary resources. Together these combinations create economies of scale and scope. While in some cases, firms use IT based capabilities to expand their operations to lower their per unit costs of service or production, some firms also use IT based

capabilities to extend the scope of their services for a very less cost. In the following, we will look at some specific IT-enabled firm capabilities that have been studied by scholars that may guide this research.

Pavlou and El Sawy (2006) study the role of IT in creation of competitive advantage in new product development (NPD). They examined IT leveraging competencies in NPD due to the effective use of process/resource management, knowledge management and cooperative work systems. Specifically, they looked at the ability of NPD work units to effectively use the available IT functionalities. They found that these IT leveraging competencies impacted the firm's ability to effectively execute operational NPD processes relative to the competition and defined this ability of the firm to convert their IT competency into an NPD competency as reconfigurability. The components of reconfigurability from this study give us an idea of the extent to which IT could be leveraged within firms – from operational coordination capabilities to more fundamental characteristics like absorptive capacity and market orientation. They guide the firm's overall functioning and strategy. Besides this study, we also draw from other researches that have shown that IT capabilities or IT enabled capabilities have led to a firm's operational or organizational innovation.

Rai, Patnayakuni and Patnayakuni (2006) studied the role of integration of firms financial, physical and information flows with that of their partners. They found that the integration of data consistency and cross functional application integration led to the creation of a functional capability in the form of supply chain process integration. This is determined by the extent of financial physical and information integration of the firm with its partners. After controlling for consumer demand predictability and firm size,

this supply chain capability was found to lead to superior operational excellence and revenue growth. Supply chain absorptive capability is another capability that has been studied in the firms' supply chains. Malhotra et al. (2005) found the positive impact of information systems in creating the absorptive capabilities in firms' supply chain. The study, conducted in the Rosettanet consortium, found that these information systems implemented along with the inter-organizational process mechanisms enhance the capability of the organization to absorb knowledge due to greater externalization, internalization, socialization, and routinization. Finally, Banker, Bardhan, Chang and Lin (2006) found that IT oriented towards automating operational activities like ERP, EDI led to development of key customer and supplier partnering capabilities.

These studies show how specific IT applications have led to development of capabilities at both operational as well as the enterprise level. In these studies the organizational capabilities that were developed were measured in a specific context of function or a process. For example, Rai et al (2006) measured the supply chain process integration capability as – (i) whether the accounts receivables is automatically triggered to customers and suppliers, (ii) whether inventory holdings are minimized in the warehousing flow and (iii) whether the inventory information is jointly available to suppliers and logistics partners. Malhotra et al (2005) measured the absorptive capabilities of the supply chain as – (i) the extent to which information of prior transactions with suppliers and supply chain partners are available in the system, (ii) the extent to which the information is used actively, (iii) the extent to which information on demand shifts, customer preferences, marketing and promotion plans are shared between supply chain partners and (iv) the quality of information exchanged. The

absorptive capabilities were measured in the context of their supply chain function and the customer and supplier partnering capabilities were measured based on the ability of the information systems of the firm to exchange information between customers and suppliers. Hence, for this study, it is important to measure capabilities of a firm that enable it to successfully innovate at the process level and at the product / service level.

Sambamurthy et al (2003) develop a theoretical model that summarizes the mechanism by which IT capabilities impact a firm at different levels. They explain that IT resources and capabilities of a firm present the manager with digital options both at the operational and organizational level. They argue that superior managerial abilities and entrepreneurial processes enable a firm to realize value by selecting the appropriate options and enacting strategic actions on those options. Thus, in the context of innovation, the selection of the appropriate actions and the enactment of strategic actions are based on the ability of the firm to effectively appropriate the knowledge behind an innovation (for example, a critical idea for improvement of a process using a technology like Radio Frequency Identification). It is also clear that the resource based view and the dynamic capabilities present a suitable theoretical base for studying the innovation impacts of IT in firms. However, innovations in firms have been a long term focus of marketing studies. Mainly, the marketing studies have extensively studied the specific inputs to the innovation process of the firm and the conditions under which these conditions are effective. In the following section, we look at the innovation and new product development literature in marketing in detail.

Innovation in Organizations

The marketing literature on organizational innovation uses many terms interchangeably – "innovation", "innovativeness" and "new product innovation". Damanpour (1992) and Garcia and Calantone (2002) synthesized the marketing literature on innovation and provided a integrated definition for "innovation" – an iterative process initiated by the perception of either a new market and/ or a new service opportunity for a technological invention or by the perception of making improvements to the extant processes of production. This definition which had been hitherto adhered to by scholars in the field, posits innovation in the light of its potential to generate new rents for the firm by enhancing or adding products and services. This may be because of the strong representation of manufacturing studies as the context within which seminal studies in innovation have been based on.

Why some industries and firms introduced more products than others has been a question of high interest in the innovation literature. They have studied how industry and organization structure characteristics affected innovation in firms. For example, scholars looked at how the level of formalization in organizational structure and the level of centralization in decision making affected innovation (e.g. Kimberly & Evanisko, 1981; Damanpour, 1991; Wolfe, 1994; Daft, 1992). They find that high levels of formalization and centralization of decision making stunted innovativeness in firms even though it improved control and execution. This informs us of the role that organizational structure and autonomy of decision making has on the innovativeness of the firm.

However, the phenomenon of innovation is dependent on not just how firms structured themselves. Differences in resources and capabilities between firms explain a lot of variance in the levels of innovation in firms. A large body of studies examined organizational innovation from this perspective (e.g., Brown & Eisenhardt, 1995; Henderson & Cockburn, 1994; Iansiti & Clark, 1994; Leonard-Barton, 1995). Both tangible (technology, special skills and funding sources for example) and intangible resources (internal communication and planning for example) were found to impact the process of innovation in a firm and thereby its ability to innovate.

As the literature matured, it is easy notice the shifting of the focus of the nature of resources studied. Within the resource oriented perspective, initial studies looked at how financial disposition of firms impacted its innovation ability (Baysinger & Hoskisson, 1989). As engineering and information technology developments kept pace across industries, technical resources were studied to be antecedents to innovation (Song and Parry 1996). Finally, scholars also looked how they organized and exchanged knowledge and information and the intangible fall-outs from therein also as antecedents to firm level innovation (Kessler & Chakrabarti, 1999). This is summarized in Figure 1.

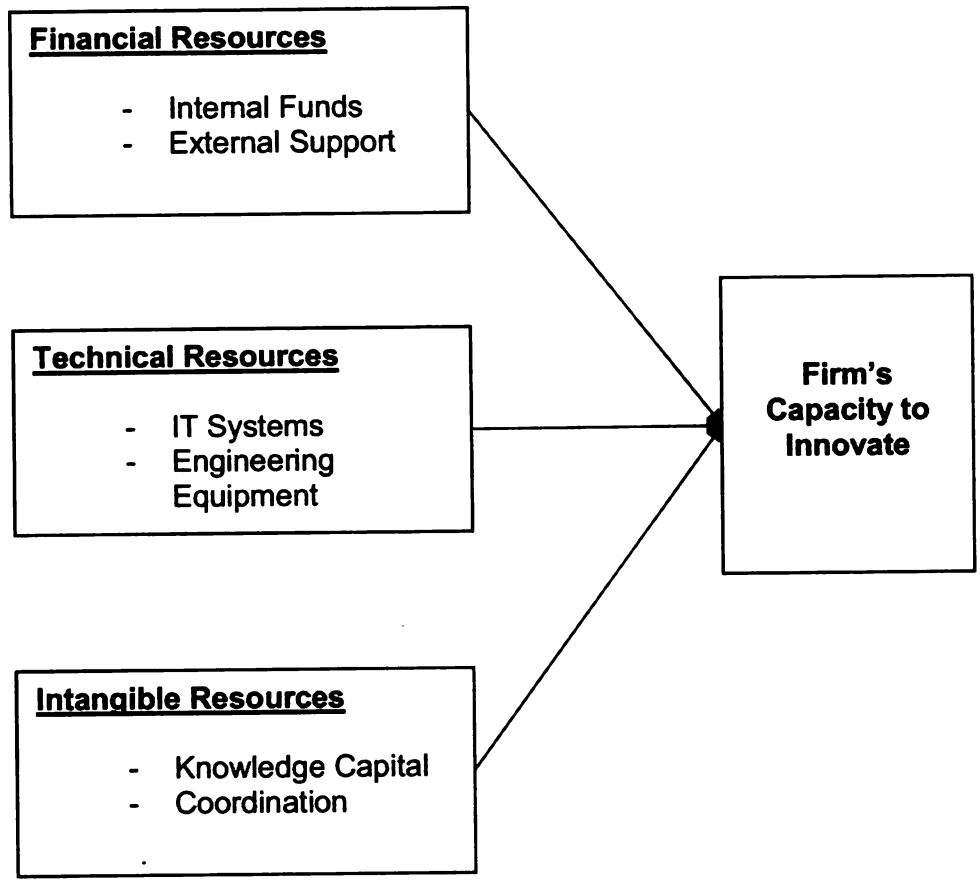
Initial management thought on organizational innovation considered innovation and innovation related activities as one indulged in by successful firms that are replete with resources. So, innovation was looked at as a set of activities in firms to effectively employ their slack resources. The availability of financial resources can expand a firm's capacity to support its innovative activities (Lee, Lee and Pennings 2001; Delcanto & Gonzalez 1999; Harris & Trainor 1995). Some studies found that innovation by firms was stunted due to lack of availability of internal financial resources (Baysinger &

Hoskisson, 1989; Teece & Pisano, 1994; Helfat, 1997). Studies on financial resources and their impact on innovation also find that internal funding of innovation projects as a key antecedent to organizational innovation. This is because of the importance of keeping innovative developments within the firm a secret as a means to gaining competitive advantage over competitors. Seeking external funding will require revealing the nature and intent of a firm's innovation activities.

Technical resources like engineering and production equipment, manufacturing facilities and IT systems have also been found to positively impact innovation in firms. Song and Parry (1996) studied Japanese firms and their innovativeness and found that technical proficiency as a key factor that distinguished the highly innovative Japanese firms. Technical proficiency reflected the ability of a firm to conduct engineering and technical assessments, building prototypes to suit specifications, conduct evaluative laboratory tests to improve technical design and their ability to design and test manufacturing innovation.

When a large emphasis is placed on why Japanese firms were better at innovating, Song and Parry (1997) found that technical skills were more available in R&D functions of Japanese firms as compared to American firms. These studies showed how engineering and technical resources and skills were important antecedents of firm level innovation.

Figure 1: Synthesis of Resource Antecedents to Innovation



More recent research on innovation has shifted attention from tangible to intangible resources. Intangible assets may be more important from a strategic point of view, since they bring together valuable, rare and inimitable (Barney, 1991; Hitt, Ireland, Camp and Sexton 2001). For example, the availability of qualified human capital with advanced technical skills, know-how in R&D projects, and risk taking propensity increases the probability of a firm to carry out innovative activities (Delcanto & Gonzalez 1999; Kessler & Chakrabarti, 1999; Song & Parry, 1997; Huiban & Bouhsina, 1998). The knowledge-based perspective places particular emphasis on the firm's stock of knowledge (tacit or explicit) as a strategic resource and an important determinant of its competitive success (Kogut & Zander, 1992; Nonaka, 1994; Decarolis & Deeds, 1999). Therefore, not only must firms be able to create knowledge within their boundaries, but they must also be open to new ideas from their external environment in order to prevent rigidity, encourage innovative behavior, and check their technological developments against those of competitors (Leonard-Barton, 1995).

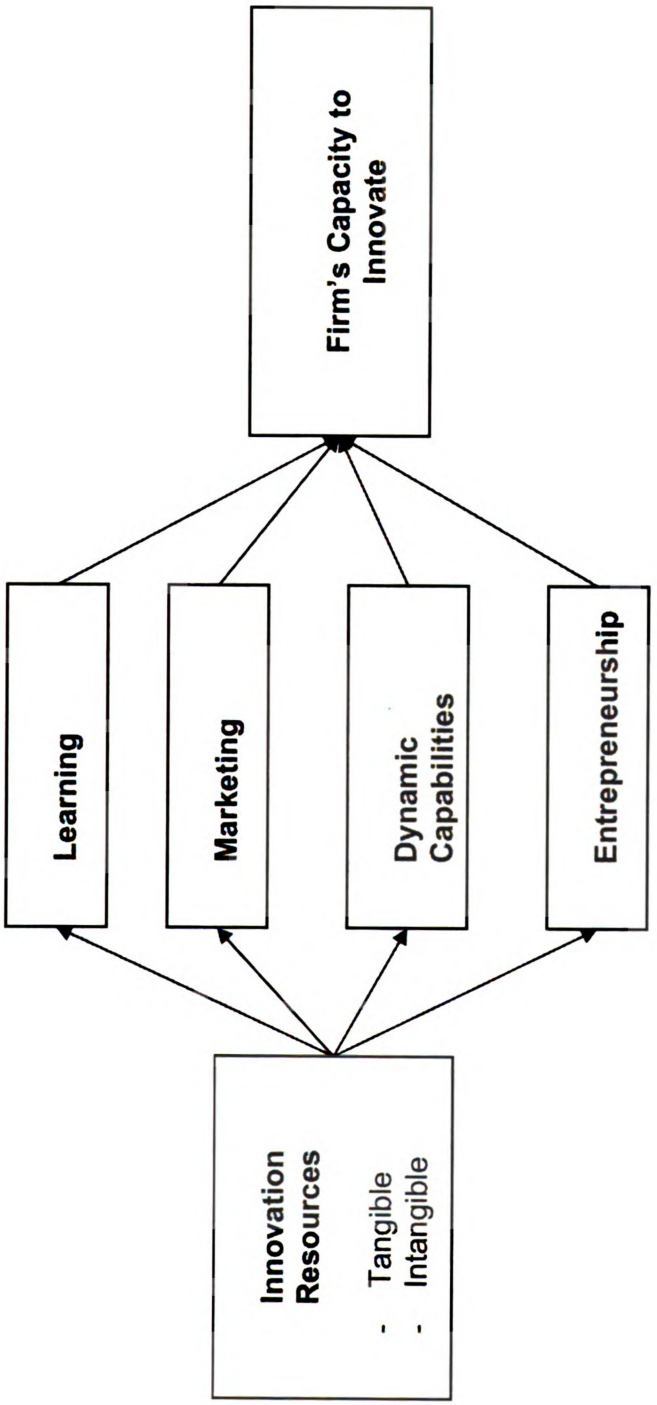
Organizational knowledge and its link to innovation has been studied in many contexts. Joyce and Stivers (1999) established the positive effects of market knowledge in their study of a sample of Canadian and US firms. Hoopes and Postrel (1999) found that shared knowledge is an important resource underlying new product success. In their study of US software industry, Li and Calantone (1998) found that thorough customer knowledge enhances new product development. Similarly, Helfat and Raubitscek (2000) argued that market knowledge could form the foundation for generating multiple new product lines. In their study of large European firms, Whittington, Pettigrew, Peck,

Fenton and Conyon (1999) confirmed that systemic change and innovation is high in organizations with increased knowledge intensity.

Entrepreneurship has also been found to a key intangible component of innovative organizations. Ahuja and Lampert (2001) show how chemical industry firms that experiment with novel technologies and methodologies pioneer in using them and hence create innovations. From a resource – based perspective, entrepreneurship enables a firm to be innovative not only by utilizing resources in a new way, but also by creating new resources (Zahra, Jennings and Kuratko 1999). Specifically, new knowledge and knowledge based outcomes like learning are more evident in studies that examined entrepreneurship and innovation in firms. Entrepreneurial firms foster an environment where unplanned activities and tasks are accommodated as a part of the existing organizational routines. This enables a greater chance for learning across the organization and serendipitous innovation within firms (Lumpkin and Dess 1996).

Firms derive value from resources by combining them with their processes thereby creating distinctive competencies. Nelson and Winter (1982) explain that such firm competencies are basically organizational routines and they create knowledge by combining tacit knowledge through path dependent learning mechanisms. Similar arguments about the evolutionary nature of firm performance had been explored in the concept of absorptive capacity by Cohen and Levinthal (1990), combinative capabilities by Kogut and Zander (1992) and most recently dynamic capabilities by Teece et al. (1997). All these studies emphasize the role of intangible resources in the process innovation. From the literature, we can synthesize that the innovation process of the firm is fuelled by many different types of resources. We show the same in the Figure 2.

Figure 2: RBV in Innovation Process



IT and Organizational Innovation

Despite progress in the understanding of innovation process in firms and the various impacts of IT, there is limited understanding about the role of IT and its impact on the innovation process of the firm. The literature on innovation in marketing has addressed IT in many different ways. Overall, two different themes seem to emerge from the literature on the role of Information technology in the innovation process of firms. First is the role of Information technology as a medium of carrying out processes within firms. Second is the role of information technology as a resource that is a co-input to the innovation process. A summary of studies that have addressed IT in the innovation process of the firm that were reviewed is presented in Tables 2a and 2b.

Studies have examined IT as a medium of operations and an exogenous factor that affects innovation. These findings from these studies have not found a clear link between IT and innovation. While some studies show that IT has helped in automating tasks and thereby improving efficiency of many steps in the new product development process, other studies show IT as a deterrent in the product innovation process. Some studies show IT as a medium in which information is well integrated and acts a good collaboration enabler between various parts of the firm thereby enabling innovation. On the other hand, some studies find that IT brings about volatility in the environment due to frequent changes and thereby disturbing the routines of innovation in an organization (Gima 2005, Zheng Zhou, Yim and Tse 2005). Even ERP technology that is known to streamline business processes within firms has been shown to bring about inflexibility by enforcing rigid workflows thereby disabling change and innovation in firms.

The second perspective examines IT as a co-input to the innovation process. In this perspective, IT is viewed as a valuable resource that an organization uses for its innovation needs. In the context of new product development, Pavlou and El Sawy (2006) explain that the primary differentiator between new product development teams lies in how the team leverages the IT functionalities and resources. Drawing on the logic that the effective use of IT functionality can facilitate information-intensive and knowledge – intensive processes, they explain that the IT competence in firms supports the new product development capabilities. Because NPD capabilities are information and knowledge intensive (Madhavan and Grover 1998), they can be enhanced by the effective leveraging of IT functionalities (McGrath and Iansiti 1998, Nambisan 2003). First, IT leveraging competence in NPD can support information processing through enhanced communication and increased efficiency of information sharing. Second, the efficiency, scope, and flexibility of NPD capabilities can be enhanced by IT leveraging competence. IT leveraging competence can facilitate the efficiency of NPD capabilities by facilitating rapid and reliable knowledge sharing (Alavi and Leidner 2001), it can increase their scope by increasing knowledge reach and richness (Sambamurthy et al. 2003), and it can enhance their flexibility by enhancing the accessibility and availability of knowledge (Zahra and George 2002).

IT functionalities and capabilities influence the absorptive capacity of innovation units within a firm. Effective use of technologies like Knowledge Management Systems (KMS) help in analyzing, coding and sharing tacit knowledge and hence makes the multiple units within a firm that collaborate on innovation projects more competent in acquiring product / service – related knowledge. IT enables the

storage of data on processes and products and helps the innovation units of the firm in articulating, interpreting and synthesizing new and stored knowledge. The IT functionalities available within a firm also may enhance the problem – solving ability of the firm and enable also generation of new thinking (Tippins and Sohi 2003, McGrath and Iansiti 1998). Information technologies also enable coordination in innovation projects by making it easier to identify available resources and providing visibility of real-time project data. Thus they enhance the ability of work units to quickly and accurately allocate resources to project tasks. The effective use of scheduling and time management functionalities makes managers more capable in appointing workers to relevant tasks and enables them to better monitor the performance of workers. By providing real-time information on project status and enabling aggregate project portfolios, the workflow capabilities can help work units become more capable in identifying synergies among their resources and tasks, better synchronizing their activities, and executing their collective activities in parallel (Sethi, Smith and Park 2001). Thus IT capabilities can enhance coordination capability within the innovation process of the firm.

Table 2a: Literature on Information Technology and Innovation - IT as a medium – Perspective

Research Study	Innovation Performance	Antecedents	Reference to IT
Laursen & Salter (2006)	Percentage of Revenue from New products	R&D Intensity, Breadth and Depth of Sources of Information	Discusses IT as a possible changer in the environment to which firms need to adapt.
Atuahene-Gima (1996)	Subjective measure of new product success	R&D Focus, Marketing proficiency, Technological Synergy, Management Support, Newness of product	Technological synergy in new products is more important for innovation success than for new services
Han, Kim and Srivastava (1998)	No of Administrative innovations and No of Technical innovations	Market Orientation	IT has been referred to as a force that contributes to environmental turbulence by affecting operations
Cavusgil, Calantone & Zhao (2003)	Financial returns and ROI.	Innovation Capability and Extent of tacit knowledge transfer	Same as above
Salomo et al (2007)	Financial Success and Project efficiency	Business planning and Risk Management	Technology has been explained as a force of change that increases ambiguity in innovation
Troy et al (2008)	Product effectiveness and Market Performance	Integration between various units in Innovation project	Technology enables fine – grained integration that fosters product effectiveness
De Luca & Atuahene-Gima (2007)	Extent to which new product objectives are achieved	Inter-functional coordination and Knowledge integration	IT has been referred to as a force that contributes to environmental turbulence by affecting operations
Atuahene-Gima (2005)	No of innovations & Financial impact of innovations (incremental & radical)	Strategic Orientation of firm and Inter-functional coordination	IT has been referred to as a force that contributes to environmental turbulence by affecting operations

(Table 2a Continued)

Zheng Zhou et al (2005)	Subjective evaluation of Firm Performance & Product Performance	Strategic Orientation, Technology based innovation and market based innovation	Technology as a component of the product that provides barriers to succeed and hence needs to be overcome with learning
Hurley & Hult (1998)	No of ideas generated by the firm (Capacity to innovate)	Team culture – Participativeness, power sharing, Learning	Technology as a component of the product that provides barriers to succeed and hence needs to be overcome with learning and joint sense-making.
Voss & Voss (2000)	Product Quality, Financial Performance of Product and Subjective evaluation of product innovation	Strategic Orientation of the firm and Inter-functional coordination	Technology in general has been referred to as a force that contributes to environmental turbulence by affecting operations
Moorman & Miner (1997)	Short term financial performance of new products	Depth and dispersion of organizational memory	Technology in general has been referred to as a force that contributes to environmental turbulence by affecting operations.
Citrin, Lee and McCullough (2007)	Subjective evaluation of product – market performance	Type of Information Use	Information technology was used as both the medium that enabled information use and as the factor that creates environmental turbulence.
Lopez-Cabrales, Pérez-Luño and Cabrera (2009)	Subjective evaluation of firm achieving financial benchmarks with new products	Collaboration and Knowledge Management practices of employees	Information technology is alluded in the paper as the medium that enables collaboration and knowledge management that fosters innovation activity.

(Table 2a Continued)

Barczak, Sultan and Hultink 2007)	Speed to market and Market Performance of Products	Extent of IT use and embeddedness of IT in the systems.	IT has been specifically identified as an enabler of innovation activity that leads to a better new product performance.
Durmusoglu, Calantone and Sambamurthy (2006)	New product development activities	IT infrastructure and product development flexibility	IT infrastructure enables flexible yet costly new product development.
Sethi (2000)	Subjective evaluation of firm achieving financial benchmarks with new products	Task interdependence and interconnectedness between departments and teams	Discusses new age information technology to enable the interconnectedness between departments and hence aid in new product development.
Massey, Montoya-Weiss and O'Driscoll (2002)	New product development process and activity	Knowledge Management Strategy and Tools.	IT enabled Knowledge management strategy was shown to radically alter new product development processes in a firm and enable it to be more innovation productive.

Table 2b: Literature on Information Technology and Innovation - IT as a Co-Input Perspective

Research Study	Innovation Performance	Antecedents	Reference to IT
Gloet & Terziovski (2004)	Productivity and Process cycle time	IT Focus on Productivity & Knowledge Management Practices	IT focus on process improvements are positively related to process innovation in firms
Gatignon & Xuereb(1997)	Extent to which new product objectives are achieved	Customer, competitive orientation, technology orientation and inter-functional coordination	Focus and use of sophisticated technologies for development of new products (i.e. technology as a component of the product)
Moorman & Slotegraaf (1999)	Brand quality improvements	Product Technology Capability, Product Marketing Capability	Technological capabilities increase speed of development and increase probability of product success. It also interacts with marketing capability to provide key synergies.
Laursen & Foss (2003)	Probability of introducing innovation	R&D Intensity, Human Resource Management Practices	Usage of Information and Communication Technologies affect innovation performance.
Prajogo & Sohal (2003)	Product and Process Innovation	Total Quality Management Practices	IT has been discussed as a tool for enforcing processes.
Gloet & Terziovski (2004)	Productivity and Process cycle time	IT Focus on Productivity & Knowledge Management Practices	IT focus on process improvements are positively related to process innovation in firms
Srinivasan, Lilien and Rangaswamy (2002)	Organizational innovativeness	Technology appropriation capabilities and IT Capabilities	IT capabilities have been explained as a complementary asset for firms specifically in e-business.

From the above review of literature it is clear that IT plays a significant role in the process of innovation in firms. Yet, the overall role of IT in the context of innovation has not yet been understood well enough. We find that even the evidence about the impacts of IT could be mixed. An integrated perspective where the usage of IT as a co – input that may foster some competencies in the firm that may serve as a medium of operations may reveal some insights into the role of IT in the innovation process of firms. Studies that have used the IT – as a co – input view and a capability enabler so far have focused on specific contexts within firms and looked at using the related information technology itself as a part of innovation. Where as, it is important to appreciate innovation as a larger phenomenon in which IT is only one of the factors. Hence, in this research we integrate the findings from the varied body of literature and study IT as a co- input that enables key competencies as a medium of execution given the various types of organizational inputs to innovation. We describe the same in the next chapter.

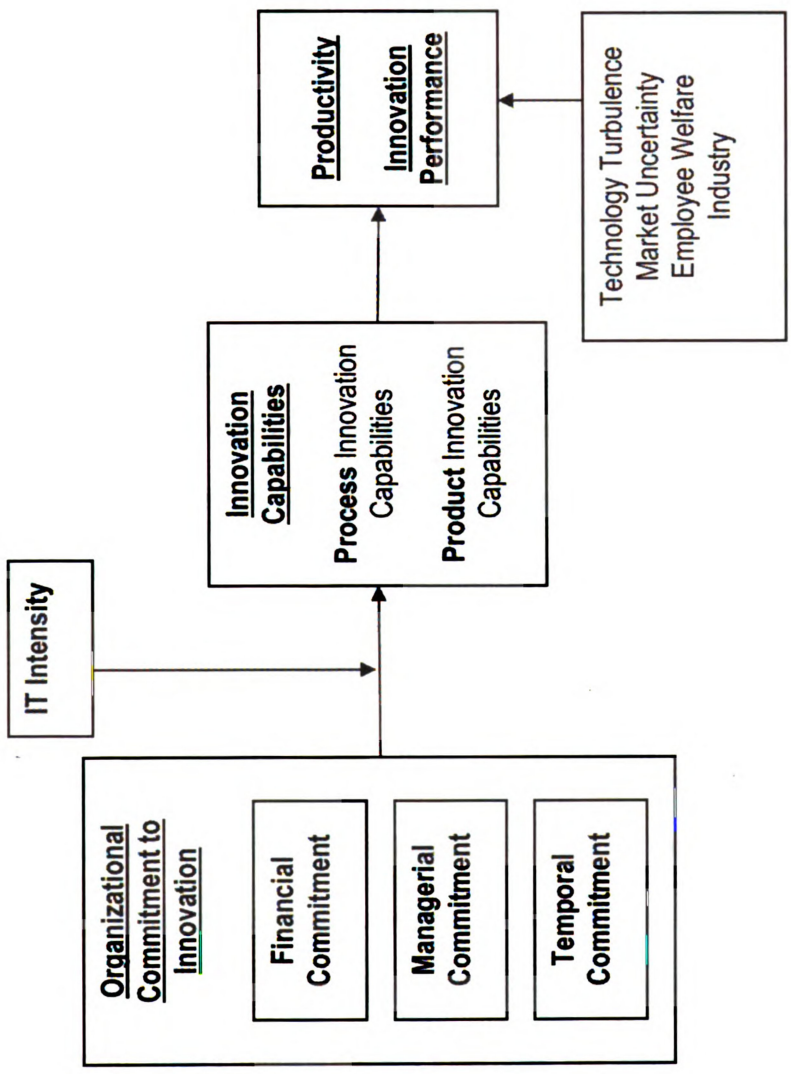
CHAPTER 3: RESEARCH FRAMEWORK

The innovation process of the firm is affected by several resources that are deployed toward innovation and information technologies are one of those important resources. However, firms differ on how effectively they derive value from their IT resources in innovation. We propose a framework based on multiple theoretical frames to study how IT affects the innovation process of the firm. In particular, we draw from the theory of dynamic capabilities (Teece and Pisano 1997) to explain that firms mainly differ in how they blend their IT resources with other inputs of innovation to enable their innovation efforts. We use the theoretical perspectives of absorptive capacity and organizational learning (Cohen and Levinthal 1990) to explain why IT resources may play a complementary role to the focus that firms show towards innovation. While the nature of these resources and their characteristics of being rare and inimitable are instrumental in firm's ability to innovate, information technologies alter the conditions that aid in creation of innovations in firm. The change that information technologies bring about in the innovation process of the firm complements the effect of other innovation resources by enabling the development of unique innovation capabilities.

Firms innovate not only by searching for newer products and features but also by clever restructuring of their production or delivery mechanisms. Accordingly, firms differ in how they combine their IT resources with other inputs of innovation. We call the ability of a firm to combine IT resources and other inputs to innovate on their production processes as the process innovation capability and the ability to combine IT and other inputs of innovation to innovate on new products and services as the product

innovation capability. In the following we explain the research framework where we describe this process. Figure 3 shows the overall research framework. The research model aims to establish IT as a resource that acts as a differentiating input into the innovation process of the firm and which along with other resources impacts the development of innovation capabilities in a firm. We look at Innovation capabilities of a firm as the main determinant of how effective innovations are in a firm. While acknowledging that firms concomitantly innovate on both their processes and on their products, we distinguish between the capabilities of a firm that are oriented towards process innovations and those that are oriented towards product innovations.

Figure 3: The Research Model



What are innovation capabilities?

Trying to understand the process of innovation in firms will require us to adopt the behavioral theory of the firm (Cyert and March 1963). Managers evaluate performance at the organizational level at which they operate (sub-firm or sub-unit level) and engage in search operations to figure points of relative low performances. Hence, managers are constantly engaged in activities that change the ways and methods of production at their corresponding levels of engagement. Organizations also engage in search for resources to gainfully employ them within their units and levels of operation. The introduction of new resources in the existing processes of operation often exposes newer possibilities and newer ways of performing the same process. In firms that are good in engaging in such search for resources and opportunities, resources have a greater chance to be diverted into appropriate projects and have a greater chance to be successful in their innovation efforts.

An organization's capability to innovate is closely tied to its intellectual capital. The intellectual capital refers to its ability to utilize its knowledge resources. Organizations adopt different types of knowledge resources that may either emanate from their human capital or from their organizational and social knowledge exchange structures (Subramani and Youndt 2005). Firms that are successful in effectively leveraging their IT toward innovation use it to integrate knowledge resources across the firm and focus it toward their ends. Organizations invest in and draw from appropriate knowledge resources to develop their intellectual capital, with a strategic need to enhance specific types of innovative capabilities (Tushman, Anderson & O'Reilly 1997). A critical portion of the knowledge and skills required for innovation resides

with and is used by individuals. The complexity of many modern innovations, however, necessitates a pooling and integration of multiple strands of knowledge. Innovation is an outcome of the knowledge and skills of personnel in R&D, marketing and engineering units. Organizations assimilate and integrate knowledge across these units by facilitating its communication, sharing, and transfer among individuals and by encouraging interactions in groups and networks. Firms where such a knowledge exchange happens more easily will benefit from a high level of absorptive capacity that spurs innovation at all levels of the firm (Danneels 2002). It is in such an exchange of knowledge and enhancement of learning that effective leveraging of IT resources makes significant differences between firms that are successful in innovation and firms that are not.

Firms show a wide variation based on the nature and abundance of resources available to them and their ability to search and accumulate resources. Firms also vary in their ability to extract innovations from the resources available to them. This variation in firms' ability to innovate is dependent upon their organizational structures and institutionalized and non-institutionalized processes. While some firms may be directing such capabilities towards enhancing their ways of functioning and their routines, some other firms may directing such capabilities towards creating and enhancing their products or services or reaching newer segments of the market. We address these variations in detail below.

Process Innovation Capability

Process innovation capability refers to the ability of a firm to be flexible in its process of production such that it can both scale to meet the demands of the market and optimize the consumption of resources. The core of such a capability is based on the focus on process management. Management of processes gained significant focus two decades ago when firms invested in managerial practices and programs like ISO 9000 and Six Sigma. Over time, managers have perfected process methodologies and practices and currently enjoy large reduction in variance of process execution and enhance control on their operation. As firms invested and improved their capabilities to manage their business processes, their ability to accommodate, adopt and execute technological innovations was affected (Sutcliffe, Sitkin, and Browning 2000). Technologies that have impacted process management in firms have helped firms document or map routines that underlie the delivery of its products or services (Garvin1995 and Harrington and Mathers 1997). Subsequent to mapping, the routines of the firm were amenable to be measured against a given metric. Hence, process management technologies helped firms in measuring and focusing on improving aspects of process structures (Garvin 1998 and Cole 1998). Process technologies not only helped in mapping and improving routines in organizations, but they also evolved to help managers in adhering to a scripted routine thereby yielding enormous process control and reducing process variation (Harrington and Mathers 1997). This aspect of process control is also evident in the findings of studies that have looked at the impact of enterprise IT systems on firms. It was found that such IT systems affected performance of a firm by reducing variance in operations and improving commonality

across different units. They also enabled enhanced visibility into how firms operated thereby promoting organization wide learning (Davenport 2000; Jacobs and Bendoly 2003; Mabert, Soni and Venkatraman 2000; McAfee 2002).

IT systems in general are embedded with standardized set of best practices for a large inventory of business processes for a number of industries (Davenport 2000, Upton 2000). Such a standardization of process knowledge helps firms to reduce operational variability and provide significant process control. Even as the implementation of technologies such as ERP or Supply chain systems provide firms with enormous process control, they enable managers to identify and recognize bottlenecks in the process execution. These systems register data from processes and thus provide "memory" of routines. Managers investing in analyzing such a "memory" of routines succeed in identifying key bottlenecks that significantly reduce operational efficiency (Cotteleer and Bendoly 2006). The implementation of such a technology impacts not only short-term improvements in process efficiencies but also enables a situation for continued learning on the process (Mooney 1995). While such enhanced control in organizations may be expected to bring about continuous improvements in the existing business processes, they may also deter making huge changes to business processes or instituting new business processes (Cadili and Whitley 2005).

Product Innovation Capability

Product Innovation Capabilities refer to the ability of a firm to leverage its innovation resources to enhance or create new products and services to satisfy the demands of the market. Such a capability is based on the firm's ability to renew its core

competencies by changing functionalities to the products that it offers or by making suitable changes to adapt to environmental factors like market competitiveness, price elasticity for its products and services and customer preferences (Teece, Pisano and Shuen 1997). Eisenhardt and Martin (2000) argued that product development is a dynamic capability because of its ability to alter the resource configuration of the firm. Product development is one of the mechanisms by which firms create, integrate, recombine, and shed resources. Product innovation capabilities involve leveraging existing and available resources that have been used by the firms normally for its innovation activities, creation of new ways to leverage from existing resources for innovation, making large shifts in technologies or business models that sustain the way the firm offers it products or services.

Firms may vary in the type and level of product innovation capabilities they develop based on the nature of learning. For example, learning structures based on internal availability of knowledge have a different impact on product innovation as compared to exploratory learning from external knowledge sources. It has been shown that while exploitative learning may be beneficial in stable environmental conditions (Jansen, Van den Bosch, & Volberda, 2006), exploratory learning may help in dynamic and turbulent environments (Lane, Koka, & Pathak, 2006). Learning processes and their effectiveness is affected by the absorptive capacity of the firm. IT improves the ability to share and exchange information - the basic components of learning processes. The enhanced memory provided by the IT resources also help improve the assimilation of new knowledge thereby enhancing the absorptive capacity of those involved in innovation oriented tasks that seek and recombine knowledge.

Helfat and Raubitschek (2000) further explained that organizational capabilities that aid in innovation co-evolve over time thereby enabling long range sustenance and advantage. Product innovation capabilities encompass marketing related skills, resources and practices, operational skills, resources and practices and R&D related skills, resources and practices and how these functional competencies are coordinated together to generate new products and execute the corresponding innovation successfully. Marketing competence of a firm spans processes that are established within organizations to decipher the trajectory of customer needs through effective information acquisition, management, and use. In addition, marketing competency involves the processes that enable a firm to build sustainable relationships with customers (Day 1994). Research-and-development competency refers to the processes that enable firms to invent new technology and convert existing technology to develop new products and services. Therefore, R&D competence depends on the routines that help a firm develop new technical knowledge, combine it with existing technology, and design superior products and services. Operations competence is focused on performing organizational activities efficiently and flexibly with a minimum wastage of resources (Krasnikov and Jayachandran 2008). The product innovation capability involves coordinating these competencies in a beneficial way to produce successful innovation for the firm's products and services.

Studies in marketing also validate the central role of learning in the development of new products and services in firms. Song and Montoya-Weiss (2001) describe cross-functional integration in the new product development context as "the magnitude of interaction and communication, the level of information sharing, the degree of

coordination, and the extent of joint involvement across functions in specific new product development tasks." Cross-functional integration can have significant advantages for the development of new products by increasing both communication frequency and the amount of information flow in the organization (Randolph and Posner 1992). Cross-functional integration pools resources and skills from different functions, providing flexibility in workforce and capital resources and enhancing the utilization of organizational resources (e.g. Ford and Randolph 1992). The ability of a firm to improve on its products and services is reflected on their attributes like quality, reliability, satisfaction, newness and uniqueness (Griffin and Hauser 1996). In our Operationalization of product innovation capability we take these factors into account.

Factors that affect innovation capability

Firms show their commitment to innovation based on the extent to which they dedicate resources of different types toward innovation ends. We treat such organizational commitments that firms make as inputs to innovation process of the firm. Following Amit and Shoemaker (1997) and Dutta et al (2005), we model a firm's innovation capabilities as its ability to transform the valuable resources into innovation. (We use the terms resources and inputs synonymously from here on). Central to a resource - based perspective is the idea that firms differ in their resource positions, and that such resource heterogeneity is a source of performance differences across firms (Barney, 1991; Peteraf, 1993). In the review of literature, we saw that firms invested in different types of resources toward innovation projects and activities. Based on that, we identify three distinct types of resources that organizations commit to foster innovation

– financial commitments, managerial commitments and ongoing – commitments. All material and human capital oriented resource dispositions are based on the financial commitments made by the firm. The allocation of financial resources into the nature of material investments is dependent upon the context of innovation, the industry and a number of other factors. Besides making financial commitments, firms also invest in structuring and organizing themselves in a way that aids their innovation agenda. Such effort is purely managerial and is key to the development of innovation capabilities. Finally, success in innovation is based on long term investments into innovation projects and hence ongoing commitments to innovation govern the development of innovation capabilities above and beyond the financial and managerial commitments that firms may make toward innovation.

Financial Commitments to Innovation

Firms allocate substantial financial resources toward various activities that are a part of innovation – R&D, technological and engineering and marketing investments. R&D expenses are the most fundamental type of financial resource commitments in firms. Much of the prior literature in both marketing and strategic management has viewed the R&D spending of a firm as a proxy for their innovation focus. Initial studies on R&D within firms centered around two basic issues – to determine pay off from R&D investments and to study determinants of R&D investments in firms. Organizational economists sought to determine whether there was any pay off at all from R&D at a societal level, at industry level and at firm level and they initially had highly inconclusive results (Griliches 1980). In the studies that focused on the

determinants of R&D in firms, the main motivation was to understand the behavior of firms as to when they resorted to search and exploration (Hambrick et al 1983). Studies reported a high correlation between R&D investments made by the firm and its innovation inputs (0.4 - 0.6) (Greve 2003). But, some firms are more successful in transforming their investments R&D into innovation outcomes that have tangible positive impacts on firm performance. The context and the process of innovation contribute greatly to predicting innovation efficiency or innovation performance of the firm. Innovation process through R&D is essentially a search process that produces many solutions for known problems. A firm launches innovations from among the set of solutions generated by the R&D process of innovation. Thus, innovation rates are affected by the supply of innovative solutions from the R&D process. Increased R&D expenditure can be channeled to the initiation of new R&D projects and to increased support of existing projects. Because the development of R&D processes and routines is evolutionary (Nelson and Winter, 1982), early investments in R&D capability usually produce a superior absorptive capacity (Cohen and Levinthal, 1990; Lieberman, 1989). Lack of investments in R&D, on the other hand, may result in lower learning capacity for a firm (Dierickx and Cool, 1989). Despite the key role of R&D investments in building and maintaining rent-producing innovative capabilities, firms differ in their commitment of financial resources to building innovation capabilities and new products. Researchers have found that inter-firm differences in R&D investments persist even after controlling for the industry, firm size, and performance (Ettlie, 1998; Mosakowski, 1993). The difference between firms in their disposition to invest in R&D

activities may reflect why firms differ in their dynamic innovation capabilities and superior firm performance.

Marketing investments refers to investments in knowledge about market size, market characteristics and market preferences. These marketing resources help in refining the existing capabilities of firms to adapt to changing environments and foster innovation (Yalcinkaya et al 2007). Specifically market knowledge has been found to be a significant complementary factor in the link between product innovation and innovation performance (Atuahene-Gima 1995, 2005; Day 1994; Li and Calantone1998). Existing markets are exploited by firms by introducing new products that rely on an existing design or technology. When new technologies alter market conditions, successful innovations using new technologies and evolution and understanding of new market preferences rely heavily on the marketing resources available with a firm. Market resources also have been found to enable market – based learning through which firms could sustain their competitive advantage by engaging in newer innovation activities (Hurley and Hult 1998, Slater and Narver 1995). This stems from the market orientation literature wherein strategic marketing scholars have identified a firm's market orientation—its ability to learn about its market environment and use this knowledge to guide its actions appropriately—as a key driver of business performance (e.g., Hunt and Morgan 1995; Jaworski and Kohli 1993; Narver and Slater 1990). The market orientation research initially aimed at studying the direct relationship between market orientation and firm performance. Since researchers found the relationship to be inconclusive, subsequent research studied and proved the role of innovation as an essential mediating step between market orientation and firm

performance (Kim and Srivastava 1998). Thereby firms that have a higher marketing orientation would invest in acquiring marketing resources that fosters innovation as a precondition to positive outcomes of firm performance. Marketing resources are not only important for their role in gathering market knowledge for successful innovation but also important in convincing managers to adopt new techniques and new processes and manage change at product and process level (Single and Spurgeon 1996). Internal marketing related studies basically concentrate on outcomes at the individual employee level and reveal that investing in internal marketing efforts has positive effects on job satisfaction, work motivation and organizational commitment, each of which is a pre-requisite for organizational innovation in firms (Hwang and Chi 2005, Bell et al 2004 and Mukherjee and Malhotra 2006).

Organizational commitment to R&D, marketing and engineering investments are key resources that directly impact the extent to which a firm may involve in product and process innovation oriented activities. The innovation activities taken up by firms are based on the existing and known set of solutions that have been analyzed and understood by their R&D departments. Product innovations in firms are normally pre-meditated and planned innovation activities (Tatikonda and Montoya-Weiss, 2001) and process – based innovations are normally based ongoing management activities that are concentrated on searching for points of inefficiency or improving quality of the process execution (Sutcliffe, Sitkin, and Browning 2000). The presence of higher levels of organizational commitments to financial resources on innovation would foster both types of innovation. More formally, we hypothesize that:

H1a: The financial commitments made by the firm toward innovation will be positively associated with the Process Innovation Capabilities of the firm.

H1b: The financial commitments made by the firm toward innovation will be positively associated with the Product Innovation Capabilities of the firm.

Managerial Commitments to Innovation

The allocation of financial resources alone cannot yield superior innovation outcomes to firms. Firms should also focus on structuring themselves in a way that the financial resources are leveraged toward innovation more effectively. The management of organizations is a continuous act of balancing short – term performance and long term adaptability not only through resource allocations but also through organizational design and structuring of incentives to innovate (Edmondson, Winslow, Bohmer and Pisano 2003, Eisenhardt and Zbaracki 1992). The process of managing a firm and making adjustments to support innovation is a complex affair. R&D activities can be described as unpredictable, human dependent, long-term and multi-staged, idiosyncratic, risky, highly uncertain, cumulative, path dependent and highly differentiated (Henderson and Cockburn 1994, Long and Ravenscraft 1993). Some studies show lack of control, loose coupling and lack of formalization as some key structural requirements for motivating innovative behavior (Hurley and Hult 1998). Organizational autonomy to units involved in innovation activities encourages and motivates innovation activities that the organizational unit may be involved in. Autonomy is also known to buttress the destabilizing effects from environmental factors like technological disruptions and organizational adjustments and restructuring (Graebner 2004 and Schweizer 2005). However, some other studies demonstrate that structure and formality are important to innovation in high-technology settings (Jelinek

and Schoonhoven 1990). Adler and Borys (1992) show that bureaucracy has beneficial effects in organizations, and Bailyn (1985) illustrates that scientists are provided with too little behavior control in their initial jobs, thereby creating job dissatisfaction. She recommends that less autonomy and some behavioral controls are important in early career stages. Managerial commitment toward innovation is about the inclination shown by the firm to meditate, analyze and make suitable structural and organizational adjustments that encourage innovation overall in the firm.

Besides the structural adjustments, a firm may also make significant changes to their strategy to foster innovation. Management literature explains that entrepreneurially oriented firms would be more innovative (Covin and Slevin 1989, Zahra 1993). The marketing literature posits market orientation as a key aspect of an innovative firm (Atuahene-Gima 1996, Jaworski and Kohli 1993, Slater and Narver 1994). Market orientation describes a firm's orientation toward the promotion and support for the collection, dissemination, and responsiveness to market intelligence to serve customer needs. In contrast, entrepreneurship orientation can be described as a learning and selection mechanism that engenders exploratory, risk-seeking behaviors in the product innovation process (Lumpkin and Dess 1996). Often, a careful alignment of market and entrepreneurship orientation processes and practices enables the firm to adapt to and manage its market environment to meet current and emerging customer needs. Similar to investing a careful analysis and structuring of a firm and its units for encouraging innovation, managerial investments also involve the willingness of the firm to identify the appropriate alignment of the firm to suitably set the incentives for various units such that it fosters innovation in firms. In summary, prior research has demonstrated that

firms that have invested in managerial resources that encourage and enable innovation are more innovative. Accordingly, we hypothesize that:

H2a: The managerial commitments made by the firm towards innovation will be positively associated with the Process Innovation Capabilities of the firm.

H2b: The managerial commitments made by the firm towards innovation will be positively associated with the Product Innovation Capabilities of the firm.

Ongoing Commitment to Innovation

Activities associated with innovation include creative work which includes a special class of "problem – solving" activity characterized by novelty and persistence. One of the characteristics of firms that are committed to innovation is to exhibit a willingness to accommodate such time consuming search by continuously engaging in the creative work. We define such commitment of a firm to continuously engage in innovation related activities irrespective of success or failure as temporal commitment to innovation. Besides facilitating the gradual and continuous process of innovation, such persistence also provides a foundation for the social norms that help in sharing and transfer of tacit knowledge and facilitate innovation in a firm. In a study that estimates a firm's innovation capability as the efficiency with which it generates process and product innovations, Dutta, Narasimhan and Rajiv (2005) find that leading innovators show significantly higher persistence on innovation than firms that trail in innovation. Therefore, we expect that a firm that is invested in innovation longer would have more evolved innovation capabilities. We present the same formally as:

H3a: The ongoing commitments to innovation will be positively associated with the Process Innovation Capabilities of the firm.

H3b: The ongoing commitments to innovation will be positively associated with the Product Innovation Capabilities of the firm.

Complementary role of IT in Innovation

IT investments made by a firm have been explained earlier to impact its innovation activities. The ability to obtain information about markets and customers helps to ensure that firms are attuned to changes in the environment (Barney, Wright, and Ketchen, 2001). Hence technologies have been studied and found to have a significant positive impact in enabling firms to collect and utilize information. For example, Customer Relationship Management applications help firms to record information on each interaction and transaction with the customers and such recorded information is used to generate knowledge about each customer (Mithas, Krishnan and Fornell 2005). Knowledge generated in this way can be used by firms to appreciate preferences of customers not only with respect to the product or service offered by the firm but also with respect to how they consume the products and services and what barriers or challenges they experience in the process (Prahalad, Ramaswamy, and Krishnan 2000). This is an example of how investments in Information Technologies enable firms to gather more knowledge and due to information processing abilities of the technology enable customer oriented product or service innovations. Information and related technologies that support not only information recording and processing but also communication have significant impacts on integrating people and units of a firm to collaborate more easily. Such ability enables innovation projects to integrate knowledge and information from various sources thereby enabling more effective innovations within the firm.

Information technologies have an ability to integrate many units of the firm and thereby coordinate the processes of production. Hence, ERP technologies were very

popular in the role they played in brining in supply chain integration and enabling seamless logistics in firms (Swift 2002). Integration of Supply chain processes with customer relationship processes ensures that products and services offered by various organizational units and suppliers are coordinated to provide a better customer experience. We also know from previous research that integration of IT systems in a firm's value chain is essential to the realization of the full benefits of seamless information sharing and data completeness (Gosain, Malhotra, and El Sawy 2005; Rai, Patnayakuni and Patnayakuni 2005). Thus, we are aware of the impacts of information technology on business processes of firms through effective information sharing and coordination. It has also been proved that ERP systems not only improve the efficiency of tasks in manufacturing processes but also bring about coordination improvements by which the quality of execution also became better (Gattiker 2005). The IT investments made by a firm significantly enable other resources of innovation in their ability to increase the firm's capacity to innovate. We explained how R&D investments made by the firm (both internal and external impacted the innovation capabilities of the firm through their ability to develop on the existing knowledge and bringing in the ability to leverage external knowledge and producing actionable innovation opportunities. The process of knowledge leverage is significantly enhanced by information technologies through enhanced information sharing. Also the increased ability to record and process data on processes enable both the R&D units and managerial resources to gain greater visibility into the operational functioning of the firm's processes and thereby enable better identification of bottlenecks and inefficiencies. The improved customer knowledge gained through CRM technology investments in firm's sales processes could

significantly complement the marketing efforts of the firm in changing either the functionalities of the products and services and to improve its selling and fulfillment processes.

From the above, it may be noticed that information technologies in an organization enable it to channelize and direct their focus towards innovations at both process and product level in unique ways that help firms to not only innovate but also give them a differentiating advantage. For example, information technologies enable innovation activities that are supported and directed by the financial resources that a firm commits to innovation. In firms with a greater commitment of financial resources, the outlay of innovation activities may be more elaborate than firms with limited financial commitments to innovation. When firms with a more intensive commitment of financial resource also shows a more intensive availability of information technologies in the organization, there is a sharper channelizing of a larger innovation outlay of innovation activities. We may expect hence information technology intensity in firms to positively moderate the fostering of innovation by financial resources dedicated by the firm.

More than just the availability of information technology, firms with a greater will to innovate and direct their resources accordingly may achieve superior leveraging of information processing capabilities of IT toward their innovation needs. Hence, a firm that shows greater managerial commitment may steer its innovation resources toward its innovation goals by leveraging information technology. Also, the impacts of information technology capabilities and in general innovation commitments yield value only over a long term period. Hence, the temporal commitment toward innovation that a

firm shows through continuous engagement in directed innovation activities may stand to have greater opportunities to yield value. Overall, we posit that the innovation related resources that firms undertake to commercialize or monetize on specific innovation opportunities are complemented by the information technologies in the firm that provide better data for improved planning and execution of innovation projects. Such complementarities provided by information technologies may be expressed formally as:

H4a: The financial commitments to innovation made by firms with higher levels of IT Intensity have a higher impact on the Process Innovation Capabilities than in firms with lower levels of IT Intensity.

H4b: The financial commitments to innovation made by firms with higher levels of IT Intensity have a higher impact on the Product Innovation Capabilities than in firms with lower levels of IT Intensity.

H5a: The managerial commitments to innovation made by firms with higher levels of IT Intensity have a higher impact on the Process Innovation Capabilities than in firms with lower levels of IT Intensity.

H5b: The managerial commitments to innovation made by firms with higher levels of IT Intensity have a higher impact on the Product Innovation Capabilities than in firms with lower levels of IT Intensity.

H6a: The ongoing commitments to innovation shown by firms with higher levels of IT Intensity have a higher impact on the Process Innovation Capabilities than in firms with lower levels of IT Intensity.

H6b: The ongoing commitments to innovation shown by firms with higher levels of IT Intensity have a higher impact on the Product Innovation Capabilities than in firms with lower levels of IT Intensity.

How do innovation capabilities matter?

Innovation capabilities reflect the firm's capacity to innovate and its ability to convert the innovations into tangible outcomes for the firm. When the innovations are

aimed at creating new processes or modifying existing ones, then the tangible outcomes are operational and "internal" and are in terms of improvements to process efficiency or improvements in process effectiveness or process quality. And when the innovations are aimed at creating new products or services or modifying existing ones, then the tangible outcomes are reliant on the commercial performance and acceptance of the new product or service alone. At the core of the Innovation capability of a firm lays the managerial ability to make appropriate decisions and effective coordination of all resources of innovations. These predominantly include intangible assets like knowledge assets and intangible investments. Further, the innovation capability of a firm not only reflects its ability to manage resources effectively to successfully complete and implement innovation projects but also on the ability to create new knowledge. These enable firms to innovate and outperform their rivals in dynamic environments (Grant, 1996; Kogut & Zander, 1992) and result from the collective ability of employees to exchange and combine knowledge (Nahapiet & Ghoshal, 1998). Also, characteristics of firm social environment facilitate such exchange and combination (Kogut & Zander, 1992; Nahapiet & Ghoshal, 1998).

Information technologies have enabled organizations to reconfigure and modify their business processes such that it is well aligned with the expectation of the customer, reducing risk in supply chain handling. Specifically, efficiency improvements in process level is studied to accrue to provide superior cost benefits to the firm thereby improving firm productivity. Process Innovation Capabilities focus on the "development" aspect of the research-and-development process and are entered into with the goal of joining existing competencies across firm boundaries to generate synergies and provide novel

and intuitive improvements to the process (Garcia, Calantone, and Levine 2003; Koza and Lewin 1998). But, the success of such an innovation product or service is measured by the commercial acceptance and impact of the product reflected by the revenues they accumulate for the firm. From the generation of new ideas through the launch of a new product, exploration and exploitation of knowledge assets from various quarters is the core capability of firms indulging in product innovation (Atuahene-Gima 2005, Holmqvist 2004, Özsomer and Gençtürk 2003, Rothaermel and Deeds 2004). Product innovation capabilities are founded on the firm's ability to diverge from its knowledge – base and capitalize on unexplored opportunities.

Both the product and process innovation capabilities of a firm are demonstrated by firms together. Firms that may show superior performance are those where the capabilities have been synchronized such that they yield value to the firm through a more efficient combination of resources. To this end, we consider two different measures of firm performance – one strictly oriented towards innovation and which has been used in prior literature in this context and one from a shareholder perspective. It is important to appreciate the value that innovation capabilities add is analyzed from two perspectives – one from a top line oriented perspective and one bottom line oriented perspective. Innovation performance of a firm oriented towards top line growth is the ability to effectively generate new opportunities of businesses. From a bottom line perspective, we consider the ability of the firm to generate revenue given the resources that it has consumed – productivity of the firm. We summarize the overall impact of product and process related innovation capabilities on the performance of a firm as:

H7a: Firms that have higher levels of process innovation capabilities will have higher levels of productivity.

H7b: Firms that have higher levels of process innovation capabilities will have higher levels of innovation performance.

H8a: Firms that have higher levels of product innovation capabilities will have higher levels of productivity.

H8b: Firms that have higher levels of product innovation capabilities will have higher levels of innovation performance.

Controls

The nature of the industries organizations compete in is known to influence their innovative capabilities. For example, manufacturing firms and service firms may tend to develop different innovation capabilities. For example, Dess, Ireland, and Hitt (1990) suggest that industry dynamism, munificence and complexity affect the nature of innovations that firms indulge in. Between manufacturing firms and service firms, we may expect to find substantial differences not only in the factors that bring about dynamism and also on the nature of assets held by both the firms (Burgelman, Maidique, & Wheelwright, 1996; Gallouj & Weinstein, 1997). Hence, we control for the basic nature of the industry the firm is in – manufacturing or services. In order to address the dynamism in the environment of the firm, we control for Technological turbulence and to account for the environmental uncertainty the firm faces, we control for market uncertainty. The quality of employees is also studied to affect the innovation nature of the firm and thus contributes to its capacity to innovate. Though many studies have used education level of employees in the firm as a proxy for the quality of human capital the firm is endowed with, we moved away from the same because, innovative

behavior may be exhibited by both educated and not – so educated human beings. We considered that firms that acknowledge the superior quality of human capital they have would have a greater interest in their welfare considering they are a valuable asset for the firm. Accordingly, we controlled for the employee welfare of the firm in our analyses. Numerous organizational factors also influence innovative capabilities. For example, large organizations may be more likely to develop innovative capabilities owing to their extensive resource bases (Henderson & Cockburn, 1994); however, smaller organizations may be more innovative owing to their flexibility (Cohen, 1995). Thus, we controlled for any extraneous effects of organization size. In the subsequent chapter where we explain the research methodology that we intend to employ to test the research model proposed herewith, we would explain more specifically on how the control variables are measured.

CHAPTER 4: RESEARCH METHODOLOGY

We have raised hypotheses to test the impact of IT on innovation capabilities of a firm across manufacturing and service industry firms. We also aim to test if process and product innovation capabilities of a firm have different types of impacts on the performance of the firm itself. Hence, we need data across a large number of manufacturing and service industry firms from a similar geographical context. It is important that the geographical context is the same because the frame of reference for testing differences in innovation approaches should be comparable. Most studies that have analyzed the innovation phenomenon have been based on specific industrial contexts and often with moderate sample sizes. In order that we have a good test of the overall impact of IT on innovation, it is important that the data spans across multiple industries and the sample size is large enough to draw a generalized understanding of IT impact. The data for this study stems from a secondary database on innovation characteristics of European firms through a bi-annual survey conducted by a third party research organization called ZEW (Zentrum für Europäische Wirtschaftsforschung or Centre for European Economic Research), based in Germany. The data used in this paper were gathered by them during the first and second waves of the innovation panel survey in 2003 and 2004. The survey itself is changed every other year based on the focus of the innovation panel at ZEW. Since the years 2003 and 2004 belong to the same survey group and is the latest survey published by ZEW, we used the same for our analysis. We could not use the data from the earlier surveys (for the years 2001 and 2002) because some of the variables that have been included in the research model were

not measured in that survey wave. The surveys for the years 2000 and 1999 were significantly different from the surveys of 2003 and 2004 and were left out of the sample. Since an adequate completion of the questionnaire required sufficient knowledge of the technology as well as of the market conditions in a particular line of business, the respondents were the Senior R&D executives of selected firms. The survey had been designed to address four main issues: (i) development and dispersion of innovative activity, (ii) development and measurement of innovative success, (iii) importance and structure of factors hampering innovation and (iv) dispersion and results of public innovation promotion activities.

The organization sent two separate surveys each year to manufacturing (MIP-M) and services (MIP-S) industry firms. The MIP-M and the MIP-S contained some questions which are repeated annually, such as those concerning process and product innovation, economic effects of innovation, R&D expenditures, investment, skill structure, labor cost, sales, and export share. On a biennial basis, additional topics such as questions on technology transfer, information sources for innovative activity and cooperations were covered. Firms that deal in marketed services like wholesale and retail trade, transport, traffic, banking, insurance, software, technical consultancy, marketing, and 'other' business-related services are grouped under services industry and firms that deal in Food & tobacco, textiles, wood & paper, chemicals, plastics, glass, ceramics, metals, machinery, electrical equipment, medical and other equipments, transport equipments and furniture are classified under the manufacturing industry. Table – 2 shows a distribution of firms across the different industry sectors in the final sample for analysis.

Table 3: Firms in the sample by Industry Sectors

Industry	Frequency	Percentage
Food & Tobacco	13	1.72
Textiles	12	1.59
Wood & Paper	14	1.85
Chemicals	48	6.34
Plastics	33	4.36
Glass & Ceramics	12	1.59
Metals	51	6.74
Machinery	85	11.23
Electrical Equipment	72	9.51
Medical & Other Instruments	67	8.85
Transport Equipment	18	2.38
Furniture	12	1.59
Wholesale	31	4.10
Retail	10	1.32
Transport & Communications	13	1.72
Banking & Insurance	17	2.25
IT & Telecommunications	56	7.40
Technical Services	125	16.51
Firm – Related Services	29	3.83
Miscellaneous Services	32	4.23
Real Estate Services	7	.92
Total	757	

Table 4: Firms in the sample by size (Number of full time employees)

Group	Frequency	Percentage
<50	183	24.497992
50 - 99	168	22.4899598
100 - 199	142	19.0093708
200 - 499	147	19.6787149
500 - 999	78	10.4417671
1000 - 4999	24	3.21285141
>5000	5	0.66934404
Total	757	

The 2003 – 2004 survey waves used for the analysis were a healthy mixture of both manufacturing and service firms – 2124 Service firms and 2385 Manufacturing firms. However, not all firms had responded to all the questions in the survey and hence could not be included in the study. Only 1017 firms had provided responses for all the data required in this research. Even in the data collected from these 1017 firms, we found a lot of inconsistencies. For example, innovation expenses and IT expenses could be expensed and accounted for by firms in different ways. However, at the firm level, we found inconsistencies in the data reported by the firms by comparing it with industry high / low and mean values for ratios between IT expenses and sales and innovation expenses and sales. We used the high / low and mean values for these ratio figures from Gartner's quarterly reports for Europe. Since we were using data from a large scale survey conducted by a third party to study specific capabilities of firms, we emphasized cleaning the data as much as possible so that the impact of measurement errors on the analysis is limited. Accordingly, we tried to identify observations that could have very high leverage or potential for impacting the fit of the model. We calculated the LEVERAGE values for all observations and marked the ones with very high LEVERAGE values. We then calculated the COVRATIO values for these observations. COVRATIO examines the precision of parameter estimates when the observation is removed. A COVRATIO value that is significantly less than 1 indicates a huge potential for the observation to impact the fit of the model. Accordingly, we dropped all observations that not only had high LEVERAGE values but also COVRATIO values significantly less than 1. We explain the models that we used to analyze the data to test the hypotheses later in this chapter. After the clean up of data, we included data from

757 firms – 320 service industry firms and 437 manufacturing industry firms for our analysis.

Measures

Since the context of this research is innovation behavior of firms and its related characteristics, I drew from the marketing and the strategic management literature to operationalize the constructs. However, not all the constructs used in the research model are used in prior research. I explain below the measures for operationalizing each of the construct in the research model and how the survey data from ZEW was used accordingly.

A firm's financial commitment to innovation is reflected by the innovation related expenditures incurred by the firm. Innovation expenditure has been used as the primary measure of a firm's propensity to innovate and is used as a proxy for innovation in prior research (Hoskisson, Hitt and Hill 1998 and Kotabe, Srinivasan and Aulakh 2002 for example). Many studies use R&D Intensity (ratio of a firm's R&D Expenses to its Sales) as an indicator of all the innovation focus that the firm shows. However, innovation related activities in a firm are not only restricted to the R&D function. Activities involving induction of innovation, marketing of new innovations and other complementary resources (like engineering & technological resources as we explained in the literature review) used by the firms to successfully realize value from a technological innovation also form the core of innovation related activities. Hence, we operationalized the financial commitments of a firm toward innovation as the ratio of

the net dollar value of all resources committed to innovation related activities in a firm in a year to the firm's annual sales – Innovation Intensity.

Managerial commitment refers to the effort taken by the management to facilitate innovation. This is often reflected by the actions that it takes like adjusting organizational structure, encouraging communication across teams, incentivizing new idea generation and sharing. For example, adopting an organizational structure that integrates the various departments involved in innovation would show a high degree of managerial commitment to innovation (Hurley and Hult 1998). Hence, we operationalized managerial commitment to innovation as the aggregate of the binary values of whether the firm has taken proactive, strategic actions in order to implement new corporate strategies and advanced management techniques, changed organizational structures and changed marketing strategies to suit their innovation goals and projects.

Firms must demonstrate their commitment to innovation over a continued period to encourage a culture of innovativeness in the firm. Accordingly, we also included ongoing commitment to innovation for an extended period. A firm with continuous involvement in innovation activities is temporally committed to innovation. We measure the ongoing commitment to process innovation using a binary indicator of if the firm has been in continuous involvement in activities targeted at developing process – based innovations. On the other hand, ongoing commitment to product innovation using a binary indicator of if the firm has been in continuous involvement in activities targeted at developing product – based innovations.

Information technology intensity of an organization refers to the level of quality of the information technology infrastructure (hardware and software) in the

organization. A firm a high levels of investment in Information technology relative to its size is high in its IT – Intensity. Accordingly, we operationalized IT – Intensity as the ratio of the firm's annual capital expenditures pertaining to information, communication and related technologies to the firm's sales.

Process innovation capability of a firm is based on its ability to adapt its production mechanisms to suit the demand and intensity of the market at optimal consumption of resources. Consequently, we measure process innovation capability using a multi – item scale that measures the focal firm's ability to – flex its production mechanisms, adapt production capacities and optimize overall labor and material costs associated with production.

Product innovation capability of a firm on the other hand is measured using a multi – item scale that measures its ability to change its range of goods and services, target new markets and improve quality and functionality of its products/services. This measure is in line with the Tushman and Anderson (1986) and Henderson and Clark's (1990) conceptualization and operationalization of innovation capabilities of firms.

Innovation capabilities may be impacted by a number of different factors both within and without the firm. However, we were careful to include those controls that are apt for a study that includes firms from a cross-section of industries. Innovation is at its core a very unstructured process that involves the involvement of motivated people (Hauser 2001). Hauser also proposed a thermostat framework whereby the incentives to people involved in various aspects of the innovation process of a firm are aligned automatically. One could expect that a firm that is reliant on its people for innovation may have a higher level of employee welfare. Accordingly, we control for the welfare

of the employees in an organization as a proxy for the level of motivated personnel involved in innovation related activities. We measure employee welfare as the ratio of employee related cost to sales.

Firms face different types of environmental conditions and pressures in different industries and their innovation behaviors may vary accordingly. Many studies (Dess, Ireland and Hitt 1990, Jaworski and Kohli 1993 and Sethi and Iqbal 2008) have addressed this by the turbulence and the dynamism of an industry. Specifically, we measure the technological turbulence faced by a firm based on two aspects – the extent to which the firm faces a technology turnover and the rate at which its products become obsolete. Market uncertainty is measured as the extent to which the managers in the firm find it difficult to estimate market demand for their products and services and the extent to which they would be required to take evasive action based on competitive actions in the market.

We see that there is a wide variation in the size of the firms included for analysis in our sample. Innovation and product development practices would differ significantly based on the size of the firms. Smaller firms may have open channels of communication and adhoc methods for product development as compared with large firms. Hence, we control for the size of the firms measured by the number of people employed by the firm. Table 4 summarizes the size of the firms used in the analysis.

Finally, the performance of a firm is measured from two perspectives – one based on the bottom line and the other based on the top-line of the firm's financial performance. We measure the bottom line oriented firm performance by the productivity of the firm. Specifically, productivity is measured using a linear scale

ranging from 10 – 80 that reflects the net revenues generated per employee. We define Innovation performance as the measure for the top line oriented firm performance of the firm. Innovation performance is defined as percentage of sales from new and significantly improved products and services. Table 5 summarizes the measures of all the constructs used in the research model for analysis. Also, Tables 6 and 7 present a summary of descriptive statistics of all the variables used in the analysis and their correlations. In the next chapter, we describe the analysis techniques and the results from our analyses.

Table 5: Summary of Measures

Financial Commitment to Innovation (Innovation Intensity) – INNOV_INT (Total Innovation Expenditure) / (Sales)
IT Intensity – IT_INT (Total Value of Capital Investment in Information and Communication technologies) / (Sales), where Information and communication technologies include hardware, software and other related equipments and services.
Managerial Commitment to Innovation - MNGRCOMMT Over the last 2 years, has your organization undertaken the following for supporting innovation activities (Binary Scales) - Implementation of new or significantly changed corporate strategies - Implementation of advanced management techniques or concepts within your organization - Implementation of significantly changed organization structures - Implementation of significantly changed marketing strategies
Ongoing Commitment to Innovation - Continuous Involvement in activities targeted at developing process Innovations (Binary) - TEMPCOMMTPr - Continuous Involvement in activities targeted at developing product Innovations (Binary) – TEMPCOMMTPd

(Table 5 Continued)

Product Innovation Capability - PRODCAP The degree to which the impact of innovation activity undertaken by the enterprise during the last 2 years: - Increased range of goods and services - Created new markets or market share - Improved quality and functionality in goods and services (4 point likert scale)
Process Innovation Capability – PROCCAP The degree to which the impact of innovation activity undertaken by the enterprise during the last 2 years: - Improved production flexibility - Increased production capacity - Reduced labor costs per produced unit / process - Reduced material and energy costs per produced unit / process (4 point likert scale)
Technological Turbulence - TECHTURB - Extent to which the enterprise is affected by rapid changes to technologies - Extent to which the enterprise is affected by rate at which its products and services become obsolete (4 point likert scale)
Market Uncertainty - MKTUNCRT - Extent to which the market demand for the products and services offered by the enterprise is unforeseeable - Extent to which the actions of competitors of the enterprise are unforeseeable (4 point likert scale)
Employee Welfare - EMPWELF - (Total Employee Related Expenses) / (Sales), where Total Employee related expenses include Salary, bonuses, training and other related costs.
Size - EMPLNO - Total number of employees in the firm
Productivity - PRODUCTIVITY - (Net earnings) / (Total number of employees in the firm)
Innovation Performance - INNOVPERF - Percentage of Sales from new and improved products and services

Table 6: Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Innovation Performance	757	27.488	28.777	2.857	100
Productivity	757	.2549538	.1532035	.02	.7
Product Innov Capability	757	3.163686	.5984387	1	4
Process Innov Capability	757	2.331902	.8810145	1	4
Financial Commitments	757	.0993395	.1000084	0	.35
IT Intensity	757	.0892206	.144411	.01	1
Managerial Commitments	757	2.072655	1.370033	0	4
Ongoing Commit - Process	757	.5706737	.4953073	0	1
Ongoing Commit - Product	757	.8428005	.3642294	0	1
Technology Turbulence	757	1.444518	.2484602	1	2
Market Uncertainty	757	1.984148	.0876635	1.5	2
Size	757	300.7693	1660.136	14	8744
Employee Welfare	757	5.998679	1.697726	1	9

Table 7: Correlations between variables used for analysis

Variable												
Productivity	1.00											
Innovation Perf	.174*	1.00										
Process Capability	.049*	-.029	1.00									
Product Capability	.013	.213*	.266*	1.00								
Financial Commit	.21	.605*	-.008	.174*	1.00							
Manag. Commit	.118*	.028	.238*	.168*	-.056	1.00						
IT Intensity	.031	.089*	.117*	.075*	.253*	.015	1.00					
Ongoing Com m-Pr	.029*	.033*	.381*	.144*	-.023	.235*	.0406	1.00				
Ongoing Comm-Pd	.01*	.161*	.036	.262*	.107*	.11*	.0082	-.037	1.00			
Tech Turbulence	-.038	-.133	-.17*	.091*	.134*	.0021	-.08*	-.11*	.13*	1.00		
Mkt Uncertainty	-.037	-.039	.004	.028	.05	.0206	.0042	-.019	.067	.0507	1.00	
Emp Welfare	-.625	.195*	-.13*	-.012	.238*	-.069	.031	-.043	.023	.111*	.031	1.00

CHAPTER 5: RESULTS AND ANALYSIS

Firms engage in process and product innovation activities concomitantly. Both of these activities draw from the same organizational resources – financial, managerial and structural. Hence, there is an endogeneity in the effects of the explanatory variables on the innovation capabilities of the firm. Correspondingly, we used multivariate regression analysis that addressed the endogeneity in the simultaneous estimation of product and process innovation capabilities. In order that the estimates for process innovation capability and product innovation capability are optimal, our empirical analysis is based on three-stage least squares (3SLS) estimation (since it uses the full information maximum likelihood estimator). The 3SLS procedure is used to derive the parameters of the full system because endogenous variables in some equations of the model are used as explanatory variables in other equations. Further, there is a possibility of correlation among error terms across regression equations due to each case being based on data from the same survey source. 3SLS combines two-stage least squares (2SLS) and seemingly unrelated regression (SUR) methods to take into account both dependent regressors and cross – equation correlation of errors. The main explanatory variables – financial innovation commitment, managerial innovation commitment, temporal innovation commitment and IT intensity of the firm were centered for the 3SLS analysis in order to pre-empt the possibility of multicollinearity due to the inclusion of interaction terms involving the same variables. The complete system of equations used to test the hypothesis is presented below. The system of equation

involves two separate assessment models – one for process innovation capability and one for product innovation capability.

PRODCAP = β_0 Constant + β_1 INNOV_INT + β_2 MNGRCOMMT
+β_3 TEMPCOMMTPr + β_4 IT_INT + β_5 TECHTURB + β_6 MKTUNCRT
+ β_7 EMPWELF + β_8 EMPLNO + β_9 INDUS + β_{10} INNOV_INT * IT_INT
+ β_{11} MNGRCOMMT * IT_INT + β_{12} TEMPCOMMT * IT_INT + $\varepsilon 1$ **(1)**

PROCCAP = β_0 Constant + β_1 INNOV_INT + β_2 MNGRCOMMT
+β_3 TEMPCOMMTPd + β_4 IT_INT + β_5 TECHTURB + β_6 MKTUNCRT
+ β_7 EMPWELF + β_8 EMPLNO + β_9 INDUS + β_{10} INNOV_INT * IT_INT
+ β_{11} MNGRCOMMT * IT_INT + β_{12} TEMPCOMMT * IT_INT + $\varepsilon 2$ **(2)**

PRODUCTIVITY = β_0 Constant + β_1 INNOV_INT + β_2 MNGRCOMMT
+β_3 TEMPCOMMTPd + β_4 IT_INT + β_5 TECHTURB + β_6 MKTUNCRT
+ β_7 EMPWELF + β_8 EMPLNO + β_9 INDUS + β_{10} TEMPCOMMTPr
+ β_{11} PRODCAP + β_{12} PROCCAP + $\varepsilon 3$ **(3)**

INNOVPERF = β_0 Constant + β_1 INNOV_INT + β_2 MNGRCOMMT
+β_3 TEMPCOMMTPd + β_4 IT_INT + β_5 TECHTURB + β_6 MKTUNCRT
+ β_7 EMPWELF + β_8 EMPLNO + β_9 INDUS + β_{10} TEMPCOMMTPr
+ β_{11} PRODCAP + β_{12} PROCCAP + $\varepsilon 4$ **(4)**

Where,

PRODUCTIVITY: Productivity of the firm

INNOVPERF: Innovation Performance of the firm

PRODCAP: Product Innovation Capability

PROCCAP: Process Innovation Capability

INNOV_INT: Innovation Intensity

IT_INT: IT Intensity

MNGRCOMMT: Managerial Commitment to Innovation

TEMPCOMMTPr: Temporal commitment to Process Innovation

TEMPCOMMTPd: Temporal commitment to Product Innovation

TECHTURB: Technological Turbulence

MKTUNCRT: Market Uncertainty

EMPWELF: Employee Welfare

EMPLNO: Log of Number of employees in the firm

INDUS: Variable coded as 1 for Manufacturing and -1 for Services Industry

The error terms in the above given system of equations estimating the innovation capabilities, $\varepsilon 1$ and $\varepsilon 2$ may be correlated with the error terms from the system of equations estimating productivity and innovation performance, $\varepsilon 3$ and $\varepsilon 4$. Hence, the OLS (Ordinary Least Square) estimation might not have the correct estimates of the standard errors and the results might be biased. Hence, our results are based on 3SLS estimation technique. Both the types of firm performance – productivity and innovation performance would be impacted by both the process innovation capabilities and product

innovation capabilities. Hence, both the firm performance variables are estimated simultaneously. In order that our estimates are robust, we used the iterative 3SLS technique where the 3SLS regression model is iterated over the estimated disturbance covariance matrix and the parameter estimates until the parameter estimates converge. Table 7, provides a detailed summary of the 3SLS analysis.

Results

The results indicate that IT intensity of a firm not only plays a crucial role in enabling process and product innovation capabilities in the firm but it is also instrumental in affecting the firm's innovation behavior. Table – 8 presents a summary of the results.

The Direct Impacts on Process Innovation Capability

The 3SLS results show that while managerial commitments and temporal commitment to process innovation activities have a significant positive impact on the firm's process innovation capabilities, the financial commitments to innovation do not have any significant impacts on the same. Accordingly, hypotheses H2a and hypotheses H3a are both supported. Further, the IT-Intensity of the firm has a significant positive impact on the firm's ability to engage in flexible and optimal production processes (β = .759).

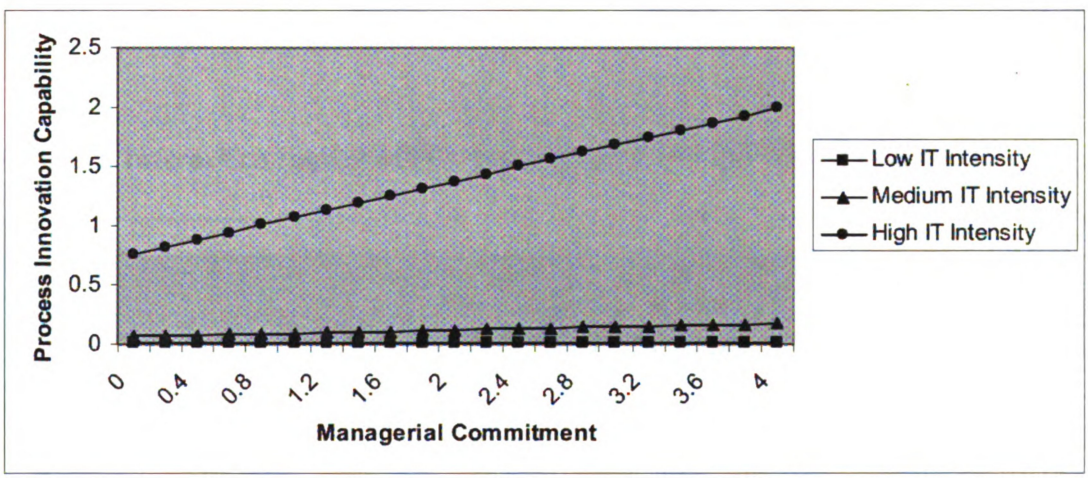
Table 8: 3SLS Analysis Results (Standard Errors are provided within parentheses)

IV	Process Capability	Product Capability	Productivity	Innovation Performance
Technological Turbulence	-.310*** (.118)	.185* (.0846)	.008 (.018)	9.768* (4.21)
Market Uncertainty	.204 (.319)	.026 (.0228)	-.0425 (.0488)	-6.49 (5.404)
Employee Welfare	-.055*** (.017)	.0109 (.012)	-.057*** (.0026)	3.184* (.607)
Size	.0000042 (.00000171)	-.000074 (.000122)	-.000068 (.000042)	.000104 (.0006)
Manufacturing / Service Industry	.153*** (.029)	.054* (.021)	-.0123*** (.0046)	-2.049*(.8865)
Managerial Commitment	.1234*** (.24)	.0626*** (.017)	.008* (.0033)	.974 (.627)
Ongoing Commitment – Process	.501*** (.068)	.140*** (.041)	.0014 (.0108)	1.595 (2.044)
Ongoing Commitment – Product	.069 (.079)	.423*** (.065)	.023 (.0144)	4.445 (2.738)
Financial Commitment	.300 (.307)	1.025*** (.262)	.0049 (.039)	173.26***(8.671)
IT Intensity	.759* (.329)	1.153*** (.404)	.334*** (.057)	14.72 (5.93)
IT Intensity * Fin Commitment	.892 (.786)	1.098* (.448)		
IT Intensity * Managerial Commitment	.307** (.0845)	.1477* (.0599)		
IT Intensity * Ongoing Commitment – Process	.775** (.039)			
IT Intensity * Ongoing Commitment - Product		.621 (.394)		
Product Innovation Capability			-.012 (.009)	6.73*** (1.46)
Process Innovation Capability			.0133** (.006)	.091 (.098)
R2	.2952	.1508	.4971	.4277
Chi2	283.51	132.18	491.94	475.43

Direct Impacts on Product Innovation Capability

The converged 3SLS results estimate that in the case of product innovation capabilities of the firm, all the resources committed to innovation in the firm have positive and significant effects. Financial commitments to innovation (β = 1.025, $p < .001$), managerial commitments to innovation activities (β = .0626, $p < .001$) and temporal commitment to product innovation (β =. 423, $p < .001$) all have positive and significant impacts thereby upholding hypotheses H1b, H2b and H3b. IT – Intensity also has a significant direct impact on a firm's ability to innovate on its products and market reach (β = 1.153, $p < .001$).

Figure 4: Interaction impact of IT – Intensity and MNGRCOMMT on PROCCAP



Impacts of Moderation from IT – Intensity

While IT intensity is found to have direct impacts on the process and product innovation capabilities, the results also demonstrate significant support for the moderating role of IT – Intensity on the innovation characteristics of the firm. The

interaction terms between IT intensity and managerial commitments to innovation have positive impacts on both process and product innovation capabilities (β = .307, $p < .01$ and β = .1477, $p < .05$ respectively). This provides support for hypotheses H5a and H5b. Also, while the interaction term of IT intensity and the financial commitments to innovation have a significant positive impact on product innovation capabilities of the firm (β = 1.098, $p < .05$), the same is not true for the firm's process innovation capabilities (β = .892, $p > .05$). These findings support hypotheses H4b but not hypotheses H4a. It is also shown that only in the case of continued investment in process innovation, is there a synergistic impact from IT – Intensity of the firm on process innovation activities (β = 775, $p < .01$). Thus there is support for hypothesis H6a but not for hypothesis H6b. Figures 4, 5 and 6 show the interaction impacts of IT – Intensity on Process and Product innovation capabilities of the firm.

Figure 5: Interaction impact of IT – Intensity and MNGRCOMMT on PRODCAP

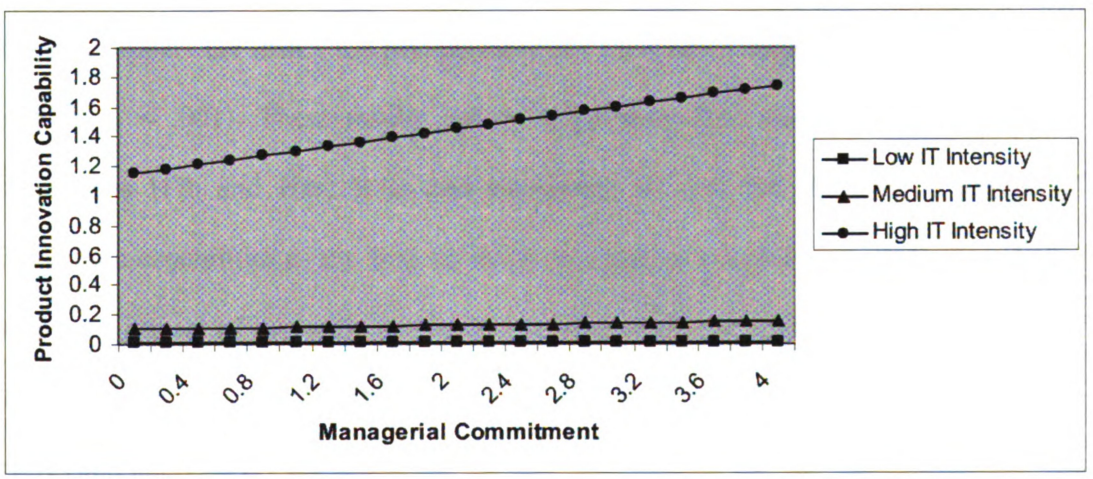
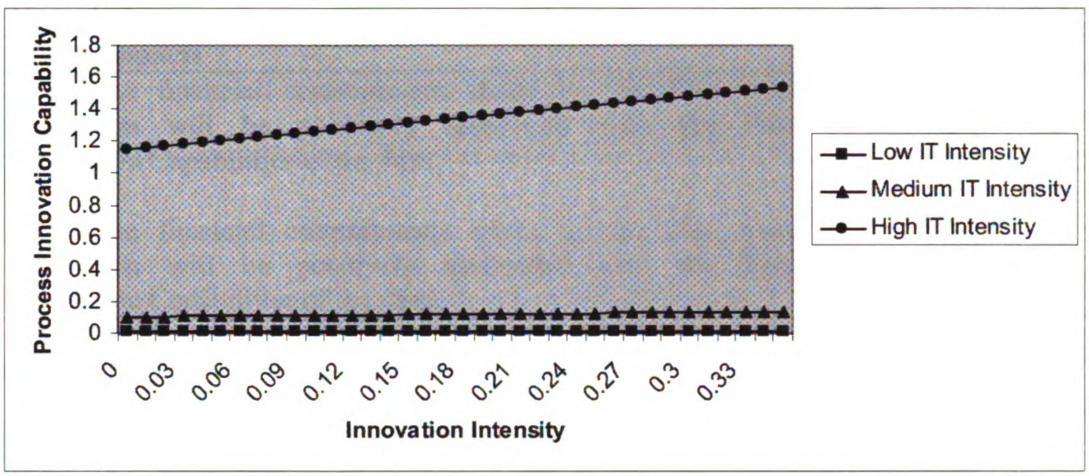


Figure 6: Interaction Impact of IT – Intensity and INNOV_INT on PROCCAP



Impacts on Firm Performance

The results of 3SLS on the impacts of process capabilities and product capabilities on different firm performance aspects are rather interesting. While process innovation capabilities are found to have impacts on the firm's bottom line oriented performance – productivity (β = .0133, $p < .01$), product innovation capabilities are found to impact the firm's top line performance indicator – Innovation Performance (β = 6.73, $p < .001$). These results uphold hypotheses H7a and H8b while rejecting hypotheses H7b and H8a. It is also interesting to note the strength of impact of innovation capabilities of the firm on the firm's innovation performance is very strong while the impact of the same on the firm's productivity is rather low (β = .0133, $p < .001$). In the section that follows, the diagnostics pertaining to the multivariate regression analyses are discussed.

Table 9: Summary of Hypotheses tests

Hypotheses	Result
Direct Impacts	
H1a: The financial commitments made by the firm towards innovation will be positively associated with the Process Innovation Capabilities of the firm.	Not – Supported
H1b: The financial commitments made by the firm towards innovation will be positively associated with the Product Innovation Capabilities of the firm.	Supported
H2a: The managerial commitments made by the firm towards innovation will be positively associated with the Process Innovation Capabilities of the firm.	Supported
H2b: The managerial commitments made by the firm towards innovation will be positively associated with the Product Innovation Capabilities of the firm.	Supported
H3a: The temporal commitment to innovation will be positively associated with the Process Innovation Capabilities of the firm.	Supported
H3b: The temporal commitment to innovation will be positively associated with the Product Innovation Capabilities of the firm.	Supported
Interaction effects	
H4a: The financial commitments to innovation made by firms with higher levels of IT Intensity have a higher impact on the Process Innovation Capabilities than in firms with lower levels of IT Intensity.	Not Supported
H4b: The financial commitments to innovation made by firms with higher levels of IT Intensity have a higher impact on the Product Innovation Capabilities than in firms with lower levels of IT Intensity.	Supported
H5a: The managerial commitments to innovation made by firms with higher levels of IT Intensity have a higher impact on the Process Innovation Capabilities than in firms with lower levels of IT Intensity.	Supported
H5b: The managerial commitments to innovation made by firms with higher levels of IT Intensity have a higher impact on the Product Innovation Capabilities than in firms with lower levels of IT Intensity.	Supported
H6a: The temporal commitment to innovation shown by firms with higher levels of IT Intensity have a higher impact on the Process Innovation Capabilities than in firms with lower levels of IT Intensity.	Supported
H6b: The temporal commitment to innovation shown by firms with higher levels of IT Intensity have a higher impact on the Product Innovation Capabilities than in firms with lower levels of IT Intensity.	Not Supported

Regression Diagnostics and Robustness Analysis

The analysis approach used is the iterative 3SLS technique where the 3SLS regression model is iterated over the estimated disturbance covariance matrix. In the analyses, the iterations were forced to converge specifically on the estimates of product innovation capability and process innovation capability. Since there was a risk of over – identification with the model, we tested whether the instruments were independent of the error process. The Hansen's J – test statistic value was found to be 36.535 at p –Val = .00722 thereby upholding the null hypotheses that the model is not over-identified. Since there were two endogenous innovation processes – process based and product based, it was imperative to test for systematic impact on variances in the model. The Breusch – Pagan / Cook - Weisberg test for heteroskedasticity were performed. The chi-sq value was not found to be significant and upheld the null hypotheses of homoskedastic variance thereby ruling out threats due to heteroskedasticity. We re-confirmed these with the B-P test following Wooldridge (2002) which does the Koenker (1983) estimation and assumes that the variation in error term is linear in the instruments. The BP – statistic was found to be 9.776 at p-Val = .094. Thereby we can rule out any threat from heteroskedasticity on the model estimation. Overall, the results indicate that IT is a very critical resource in the process of innovation. However, depending upon other resources at disposal for innovation activities in a firm, they aid in the development of specific types of innovation capabilities – some process oriented and some product oriented. The results indicate that IT enables innovation by amplifying the firm's innovation focus. In the next chapter, we discuss in detail the results and its contributions for research and what it implies for practice.

CHAPTER 6: DISCUSSION AND CONCLUSION

The principal motivation of this research was to study the impact of information technologies on the innovation process of a firm and their effects on firm performance. It also looks at how this impact matters for the firm. The study was oriented towards positing the role of Information technologies in facilitating innovation behaviors. Specifically, three different types of resource commitments were considered as the main inputs that a firm makes toward innovation – financial resources, managerial resources and time. We enlarge the scope of innovation to include improvements that firms make to their operational mechanisms – process innovations. We consider process innovations also as a key innovation capability that firms build up in addition to innovation based on creating new products and services.

Since the study is based on cross sectional data, we may not be able to examine causal relationships. Nevertheless, we find strong evidence that firms that are intensive in their use of information and related technologies also show high levels of innovation capabilities. In this section, we discuss the results in detail – the factors that directly impact innovation capabilities and the also the moderating impacts of intensity of information technology in firms on innovation capabilities.

Direct impacts on Innovation Capabilities

The financial commitments made by firms toward innovation related activities were found to significantly impact the product innovation capabilities. They however did not have any significant impact on ability of the firm to be successful in process

based innovations. The financial commitments made by the firm primarily include R&D expenses towards all creative work undertaken on a systematic basis in order. These expenses were incurred by firms in the sample to increase the stock of knowledge to devise new applications, acquisition of machinery and other hardware to support the creative work, acquisition of patents, licenses, trademarks and other types of knowledge assets to support the creative work and procedures and preparations to realize the actual implementation of the new applications that stem from the creative work. Such activities are specifically targeted towards development of new applications and knowledge within firm that form the basis of new products and services. Hence, the financial commitments towards these activities show a significant impact on the firm's ability to introduce new products and services and expand its markets. Process based innovations are based on clever adjustments to production processes that yield immediate value. The findings reaffirm those from existing literature on the impacts of new product oriented R&D activities of a firm on its performance (Chesbrough 2003, Prahalad and Krishnan 2009).

The managerial commitments made by a firm towards innovation within the firm are found to have significant impacts on both the product and process innovation capabilities. The managerial commitments made by the firm include large scale changes such as – changing firm's strategy (both at the corporate level and at the marketing level) to encourage innovation and changing the organization structures to motivate innovation. These changes contribute to not only creative thinking within R&D units but also within the entire organization. Hence, the managerial commitments made by a firm may not only encourage and enable development of product innovation but also

encourage employees involved in routine production aspects of the firm to be creative in process innovations. Hurley and Hult (1998) explain innovation as an organizational learning process that is in concert with the various structural properties of the firm. The innovativeness of a firm based on such structural and cultural aspects combined with the resources create a greater capacity to innovate. The results of this study also supplement this finding and clarify that the capacity to innovate may be both at the process level and at the product level.

Results show that a firm's continued involvement in innovation activities impact its product and process innovation capabilities. Specifically, the continuous involvement of a firm in process innovations has a significant positive impact on both product and process based innovation capabilities. However, the continuous involvement of a firm in innovation activities has a significant impact only on product innovation capabilities. Continuous involvement in innovation reflects the focus shown by the firm on innovation in the firm. Given that innovation is an unstructured process whose output may be difficult to govern, firms that show greater persistence in their innovation efforts may exhibit better innovation capabilities. Drucker (1985) proposed that, "Innovation requires diligence, persistence and commitment in addition to talent, skill and knowledge". The temporal component of innovation focus shown by firms has not been addressed directly in the prior literature. In this study, we treat the persistence of innovation in firms continuously over a period of time as a specific explanatory variable and validate its importance in the process of innovation in firms.

Complementary effects of IT

In order for a firm to carry out its innovation effectively, several units must collaborate by sharing information and knowledge. Firms that have invested substantially in Information technologies may have a greater chance of integrating information across several departments and units that may need to collaborate for either process or product innovation related activities. IT intensity is shown to moderate the effectiveness of all types of commitments that firms make toward innovation. Specifically, the managerial and temporal commitments made by an organization toward innovation have a significantly higher impact on innovation capabilities in firms that have a higher per capita availability of information technology. However, results also show that IT intensity of a firm does not generate synergies with the financial commitments that firms make toward innovation. This is an interesting result because financial inputs to innovation are the most popular among innovation studies. It is also interesting that managerial and ongoing commitments are more valuable for innovation than financial resources to leverage value from IT.

The communication capabilities of information technologies expand interaction amongst users and facilitate transfer of knowledge. The decision – aiding capabilities of information technologies enable easier retrieval, analysis and presentation of information that would help generate new knowledge. Businesses today are much more complex due to globally dispersed teams and global markets. Information and communication technologies help modern businesses handle such complexity deftly by offering novel solutions. For example, web services technology enable a firm to integrate seamlessly and easily with its stake holders in the supply and information

chain effectively. Firms in which there is a larger presence of information and communication related technologies may be able to have greater access to both the communication capabilities and decision – aiding capabilities of IT. Such integration may foster process based innovations by enabling the several units involved in production aspects of the firm and may foster product based innovations by integrating the R&D with other related units like marketing and engineering (Song 2001). Pavlou and Elsawy (2006) explain the various functions within a firm's innovation efforts that may leverage capabilities of information technologies – project and resource management, knowledge management systems and collaboration systems. This study performs a higher level analysis of the role of IT in not only new product development but also process innovation contexts. As Mata, Fuerst and Barney (1995) explain more than the capabilities of information technologies themselves, the managerial IT skills developed within an organization can yield competitive advantage. Such managerial knowledge develops over a long period of time only in an environment that munificent in information and communication technologies.

Innovation in Manufacturing firms versus Service firms

Innovation theory has been usually developed by extending the research approach to innovation in the manufacturing industry to embrace innovations in services as well (Gallouj &Weinstein, 1997). Even in the research on innovation in manufacturing industries, studies have largely focused on technological innovations – both radical and incremental. Hence, innovations were considered to be outcomes of the firm's effort to adapt to a new technology platform or evolve a product based on a given

technology platform. The emphasis on organizational innovations was significantly low. However, some studies have addressed organizational innovations (Gadrey et al 1995) and it is interesting that in all those studies, service industries have been used a context for their study. Van der Aa et al (2002) synthesize the concept of innovation in service industries and arrive that innovation within firms takes four different forms – multiunit organization, new combination of services, customer as co-producer and technological innovations. Out of these, only technological innovations are common to how prior research has addressed innovation in manufacturing industries. The remaining forms of innovations either bring about "service" lines of business within manufacturing firms or are more prevalent in service firms. Central to the understanding of a service industry firm is its reliance on providing intangible yet measurable value to its customers as compared to manufacturing industries. Hence, the routines of operation in a service firm are central to how it may be able to provide value to the customer (Pentland and Rueter 1994). Correspondingly, we may expect service firms to be more oriented toward managing the processes of production and the various routines that govern their operations rather than towards technological product innovations. However, results show that process capabilities are developed to a higher level in manufacturing firms than in service industry firms. This may be because of the fact that technologies in manufacturing firms are by and large more oriented towards operational adjustments to produce products faster and cheaper. Considering that the results hint at divergence from extant findings and expectations, innovation in service industries in comparison to manufacturing industries need to be studied in greater detail.

Differences of IT impacts on Innovation in Manufacturing versus Service industry firms

In the IT literature, a large number of studies that have studied the intermediary and process level impacts of information technology in firms in the business value of IT literature than the impact of information technology on product innovation (See Table 1). We argue that IT plays two central roles in the process of innovation. One the one hand, it enables better coordination amidst units involved in an innovation project – the marketing department, the R&D department and the external R&D units. And on the other, we explain how IT provides a platform for continuous improvement and increased governance of production processes in a way that enhances the efficiency and the effectiveness of the process. This dual role played by IT investments needs to be studied more carefully. For example, Durmusoglu et al (2006) argue that it is difficult for IT departments within firms to satisfy the demands and needs of an NPD team because NPD units are cross – functional and deals with large number of members with unique and specialized information. However Klein et al (1998) and Murray (2003) explain how computer – based techniques enable large volumes of relatively objective data to be collected and analyzed in an efficient manner within innovation projects. Hence, even though we expect increased use of IT tools within the organization to enhance product innovation related outcomes like speed of innovation, innovation flexibility, reduction of new product development risk etc, the idiosyncratic nature of innovation teams may restrict the positive effects of Information technology. For example, Benner (2009) explains how when innovation happens in photographic films industry based on incremental technological changes, process management techniques

and practices like ISO 9000 have a positive effect. However, when the innovation involves radical shifts between technologies, process management technologies and practices stunt the speed of innovation (Lavie 2006). Christiansen and Varnes (2007) explain product innovation to be based on a sense-making process. They also explain how structures within organizations that guide routine operations and business processes help in the sense-making process and contribute to evolution of product innovation. The impact of Information Technology on process management and its ability to act as a platform for continuous process improvement is well documented and accepted (Gattiker and Goodhue 2005). This is primarily based on the learning effects that are associated with usage of information technology tools and the newer avenues to improvement that become visible to managers due to increased absorptive capacity enabled by IT. Garvin (1998) and Cole (1998) explain how firms succeed in registering routines within the technology that is implemented and how the adjustment to the technology helps in tuning the routines and changing its structures.

Research on the Business Value of IT within Information Systems has found significant evidences in the role of Information technology in providing process level impacts – increasing process efficiency, reducing cycle time, reducing errors (Mukhopadhyay et al 1997, Coteleer and Bendoly 2005 etc). Research in Marketing has studied the factors that enable firms to innovate and it has identified information sharing and Knowledge Integration as key impacts on the process. Studies on organizational learning and knowledge management in new product development have shown that recording information from past product development projects influences performance (Akgun Lynn and Reilly 2000; Lynn, Simpson, and Souder, 1997; Lynn, Skov, and

Abel, 1999). More recently, Sherman et al (2005) also demonstrated how knowledge management aided by information technologies help in inter-functional coordination in New Product Development processes. Given the dual nature of the impact of IT on the development of Innovation capabilities within the firm, it is important to empirically test whether IT is a greater enabler of process or product innovation within an industry. Based on the arguments placed earlier that Service industry firms may be more oriented towards enhancing their processes rather than create newer products, we may expect that firms in services industry may leverage IT to a lesser extent towards product innovation as compared to manufacturing industries. Given that this will give important insights into leveraging of value from IT between firms in manufacturing versus service industries, it is important that future research study these differences in detail.

Limitations

The study has a few limitations. Firstly, the data for this study came from a survey conducted by a third party – ZEW of a number of European firms. Though this presented a unique opportunity to get access to data on innovation characteristics and details of a large number of firms from various sectors and sizes, it did come with the handicap that is common to most organizational surveys. The surveys were mostly single – respondent and hence, common method bias may not be ruled out. To a certain extent the bias may be considered to be minimal because of the length of the survey and given the fact that the survey several different attributes of the firm and its innovation characteristics. Innovation related information is difficult to obtain from firms as they are either kept secretive or not tracked properly and access to a large sample of firm's

innovation related data is not guaranteed in a new survey. Hence, the data source that we utilized helped us to optimize the tradeoff between rigor and reality in collecting the data for this research from a substantially large number of firms than most other studies in innovation. The second limitation of this research is also related to the data source. Due to strict privacy related concerns, the identity of the firms on which we obtained from the innovation panel surveys conducted by ZEW, was not revealed to us. This did not allow us to access data on those firms from any other data source to get complementary data on the financials of the firm. Particularly, it did stop us from being able to obtain profitability and other cost related data of the firm that may have helped extend our analyses. Third, while none of the constructs measured in this survey were perceptual in nature, it does not rule out the possibility that different firms interpret some of the questions in the survey differently, thereby introducing a systematic error in the data. Particularly, the variables that reflect the environmental conditions of the firm – technological turbulence and market uncertainty may have been subject to this bias. Finally, this research would be best conducted with a longitudinal data since innovation is a long term strategy and may be expected to have lagged impacts. Though, we draw from a multi – year survey of innovation in firms, we yet do not have a panel data on innovation behavior of firms and the analysis based on a cross-sectional data on innovation characteristics of firms. Hence, the relationships that we seek to establish can at best be claimed to be associative in nature.

Contributions

This research draws heavily on marketing, strategic management and information systems scholarship to address IT intensity of a firm as a significant aspect of a firm's overall innovation agenda. In the process, it makes significant contributions to both information systems and marketing literature. The role of IT in adding value to businesses has been studied in information systems for a long time now (Kohli and Devraj 2003). However, barring a few exceptions most studies have looked at information technologies as those that provide value by abetting the activities that are at the core of production aspects of the firm like – supply chain, demand forecasting, customer service etc. Prior research also has demonstrated that information technologies complement not only transactional routine activities of production but also higher level decision making activities. Even so as the applications of information technology to both these type of activities is the process of innovation, the aspect of how firms innovate and if information technologies have impacted it has not been directly studied. To this end, this study makes a contribution by explaining that the IT intensity in firms encourages different forms of innovation in firms by complementing the focus and commitment that a firm shows on innovation.

From a marketing literature perspective most studies have considered IT intensity as an environmental condition that may affect the innovativeness of the firm but few have addressed directly the role that it plays in the mechanisms that underlie product or process innovation in firms (Song et al 2001, Song et al 2007). This study addresses that gap by analyzing in detail the role played by the intensity of investments made by a firm on information technologies on its innovation behavior vis – a – vis the

resources deployed by the firm towards innovation. Also, firms engage in process and product innovations at the same time. The focus that the firm shows towards innovation is composite of not only the new product development activities but also process adjustments and optimization activities. In this study, we have looked at the innovations in firms' composite of both these types and go on to show how their impacts on the firm are drastically different and how IT intensity may enable both in different ways. Finally, seldom have studies on innovation had significantly large sample sizes. Since innovation related data on firms is hard to acquire, sample sizes of studies on innovation are more modest. Due to the unique nature of the survey that we have used, our study benefits from a sufficiently large sample size of firms across industry sectors and across size ranges. Thus, this study provides a generalizable validation of prior research that it has benefited from.

Managerial Implications

The value that information technology investments bring to a firm has been long established. Even markets recognize the announcements firms make on their IT investments and prior studies have shown how that has reflected in the value of the firm's stock value or Tobin's q (Bharadwaj 2000, Mani and Walden 2001). Our study not only reaffirms the value of information technology as is accrued due to immediate process control and resource optimization but also due to enablement of new product or service development. This would mean that especially firms in innovation intensive industries, the extent of IT investments made by the firm signals the conditions that favor innovation within the firm.

Further, the study provides significant clarifications to the top management towards the understanding of conditions under which different types of organizational resources favor which type of innovation in firms. While managers may appreciate that the organizational enablement of innovation is very important to complement the R&D and other innovation related expenses, most often they restrict such organizational, structural facilitation of innovation to only those employees who have an agenda of innovation in their job responsibility. However, the results from this study show that such managerial enablement has not only a positive impact on new product development in firms but also on process related improvements. Hence, extending the organizational and structural facilitation of innovation across the firm may yield innovation outcomes at different levels.

When information technology investments are made in firms, it is often accompanied by very rigorous return on investment calculations and a listing of all the tangible and intangible value – additions. Seldom have managers realized the enablement of innovation that IT investments may bring about beyond the context in which a certain technology is being adopted in. For example, a technology that may help customer support process is often justified by the improvements in metrics of customer support and the overall cost savings associated with it and the intangible value add in the quality of customer support. However this study, shows how the technology may not only help with improving the customer support process but also enable more value adding innovations at the behest of the information generated from it.

In conclusion, this study may help managers realize the vital role played by investments made towards information technologies in deriving value from their

innovation focus. And given such a moderating role of IT intensity of a firm, managers may adjust their innovation strategy depending upon the industry sector their firm is in to a more IT centric one.

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