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IT and Firm Agility: An Electronic Integration Perspective

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Abstract

Firms evolving in increasingly turbulent environments need to respond to market threats and opportunities with speed. At the same time, firms implement numerous information technologies (IT) in the hope of streamlining processes and providing managers with unfettered access to information from both within and outside the firm. While research shows how agility and IT contribute to firm performance, the relationship between these two constructs remains relatively unexplored. Using an electronic integration perspective, we develop a framework that addresses this issue. The framework suggests that IT applications affect the two components of agility (sensing and responding) through two types of integration (internal and external). The framework also explains the mediating roles of knowledge exploration, knowledge exploitation, and process coupling. Four propositions are developed and illustrated with different examples. Avenues for future research are developed.

Keywords: *Electronic Integration, Firm Agility, Knowledge Exploitation, Knowledge Exploration, Process Coupling, Sensing, Responding.*

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1. Introduction

Firms invest substantial sums of money in IT with the hope of increasing efficiency, effectiveness, productivity, and profits (Banker, Bardhan, Chang, & Lin, 2006; Davamanirajan, Kauffman, Kriebel, & Mukhopadhyay, 2006; Mukhopadhyay & Kekre, 2002; Oh & Pinsonneault, 2007). With the recent surge in environmental turbulence, increased competition, volatile consumer demand, and rapid product obsolescence, firms are also increasingly concerned with their agility, that is, the ability to sense and respond to opportunities and threats with ease, speed, and dexterity (D'Aveni, 1994; Goldman, Nagel, & Preiss, 1995).

Our understanding of the relationship between IT and firm agility is limited. Most literature on the IT business value to date has largely overlooked agility as a potential outcome, focusing instead on standard firm performance metrics (Oh & Pinsonneault, 2007). The literature on agility has mainly focused on conceptual concerns and, more recently, on the benefits of agility (Galliers, 2007; Hitt, Keats, & DeMarie, 1998; Overby, Bharadwaj, & Sambamurthy, 2006; Rai, Patnayakuni, & Seth, 2006; Sambamurthy, Bharadwaj, & Grover, 2003; Weill, Subramani, & Broadbent, 2002). The few papers that have looked at the link between IT and agility suggest a positive relationship (Sambamurthy et al., 2003; Tallon & Pinsonneault, 2011). For example, IT was found to allow firms to sense their customers' needs and respond to their needs through close collaboration with suppliers (Rai et al., 2006). Dell used IT to blur organizational boundaries with its suppliers and improve its ability to sense and respond to opportunities and threats in the market (Magretta, 1998).

This paper extends the literature by analyzing the link between IT and firm agility through an electronic integration perspective. We suggest that the relationship between IT and agility depends on the degree of electronic integration (i.e., the degree to which IT applications work as a functional whole with other internal and/or external IT applications) achieved in a firm. Electronic integration affects agility because it facilitates the efficient and effective communication and sharing of specialized knowledge among distinct organizational components (internal integration) and with suppliers and customers (external integration)¹. Electronic integration also facilitates the coordination of process activities, both within a firm and with its business partners and customers (Barki & Pinsonneault, 2005). Thus, we expect that two factors – how knowledge is used and how processes are coupled – play an important mediating role in the relation between IT and firm agility (Dyer & Singh, 1998; Saraf, Langdon, & Gosain, 2007).

Our paper contributes to the literature in three ways. First, we develop an electronic integration perspective to explain the effects of IT on firm agility and, as such, we extend Sambamurthy et al.'s (2003) work on the topic. Second, the paper explains how IT affects the two capabilities of agility (i.e., sensing and responding) through the mediation of knowledge exploration, knowledge exploitation, and process coupling. This mediation process seems key to understanding the relationship between IT and firm agility. Finally, the paper contributes to the literature on the business value of IT by showing how IT affects an intermediate outcome variable (agility), which, in turn, is likely to affect the typical organizational outcomes studied in the extant literature (e.g., efficiency, cost, profit, revenues) (Tallon & Pinsonneault, 2011).

The rest of the paper is organized as follows. Section 2 presents our framework and the propositions that link integration to agility through the mediation of knowledge exploitation, knowledge exploration, and process coupling. Section 3 presents the discussion and section 4 the contributions of our paper. The paper concludes by elaborating some avenues for future research.

2. A Framework of Electronic Integration and Firm Agility

Electronic integration facilitates agility because it increases the transfer and sharing of data, information,

¹ Note that these two types of electronic integration are not mutually exclusive, as IT applications typically facilitate both types at different degrees. For example, enterprise systems often contain modules that support internal and external integration. CRM and SCM systems mainly provide external integration, but they can also have links to internal modules. Inventory systems, on the other hand, mainly provide internal integration, but they can also have connections to vendors, thus providing external integration (Barki & Pinsonneault, 2005; Saraf et al., 2007).

and knowledge (Gosain, Malhotra, & El Sawy, 2005; Saraf et al., 2007). Specifically, the literature (see Appendix A) suggests that electronic integration might affect agility because it allows knowledge exploitation (i.e., using and sharing knowledge existing within the firm) and knowledge exploration (i.e., acquiring new knowledge from the environment). Electronic integration is also likely to affect agility because it improves the ability of firms to coordinate and seamlessly synchronize process activities (Espinosa, Slaughter, Kraut, & Herbsleb, 2007) and to execute complex tasks that draw upon the specialized expertise often spread across the firms. As suggested in the literature on business processes (see Appendix B), electronic integration improves the coupling of business processes among units (Overby et al., 2006; Sambamurthy et al., 2003).

Electronic integration can be conceived of as being composed of two primary types (internal and external, see Barki and Pinsonneault, 2005)², each of which affect the two capabilities of firm agility differently. Internal electronic integration links units within the firm, and it is likely to enable responding capability because it allows better coordination among units and makes them more adaptive to one another (Malhotra, Gosain, & El Sawy, 2007). External electronic integration allows firm to connect with business partners such as customers, retailers, and suppliers. It is likely to enable firm sensing capability by improving environmental scanning through improving probing, exploring, and appropriating new knowledge.

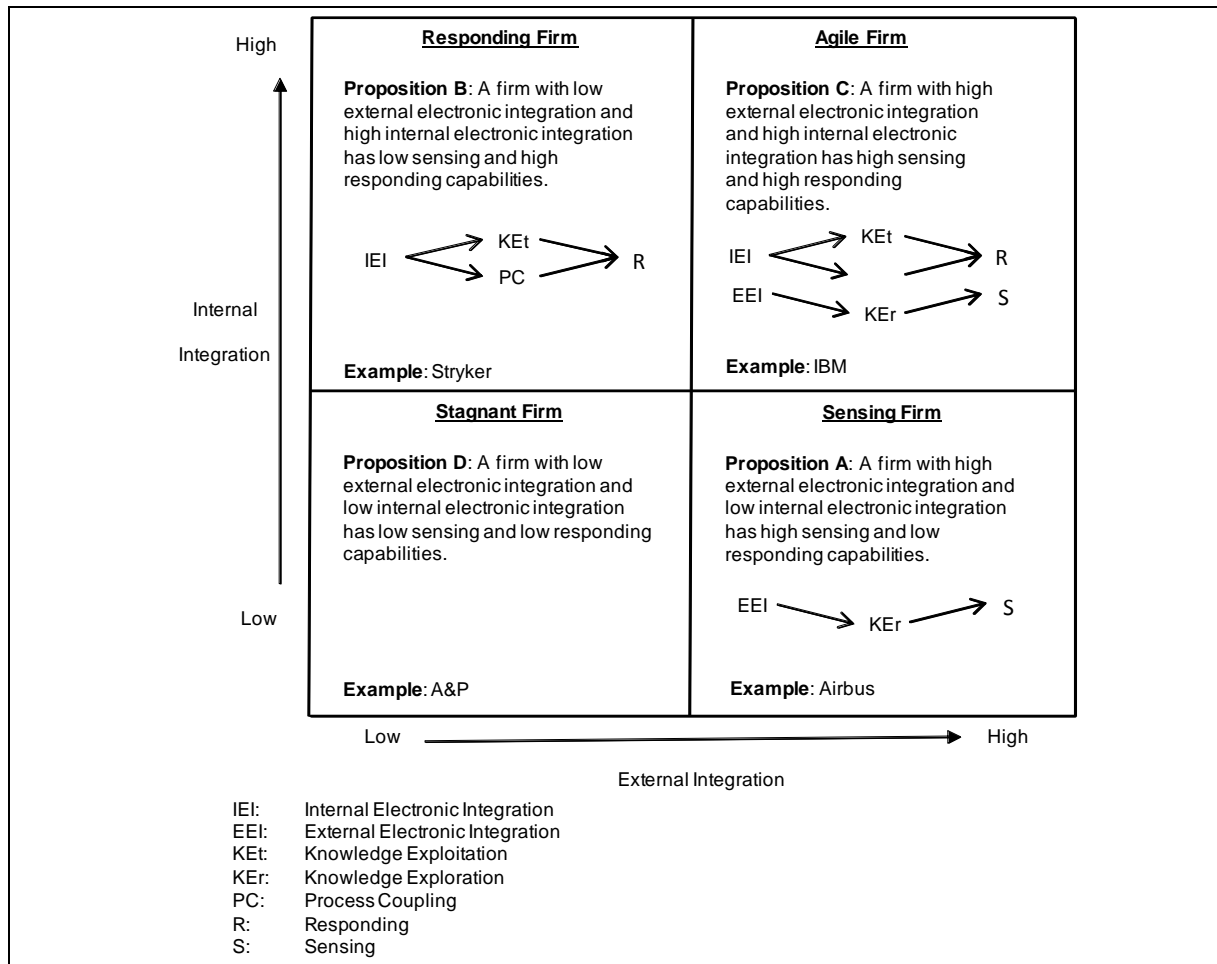


Figure 1. Combinations of the Two Types of Integration

² It is important to note, however, that the distinction between internal and external integration can sometimes be blurred, and it might be difficult to establish where exactly internal integration ends and where external integration begins. Since our paper is exploratory in nature and in order to simplify our argument, we focus on the four cells created by combining the extreme ends of the two continuums.

Combining internal and external electronic integration can, thus, provide insights to understand the link between IT and agility. The framework (Figure 1) consists of a 2 x 2 matrix with internal integration on the y-axis and external integration on the x-axis. Each of the four quadrants represents a unique combination of integration types that translates into differential effects on firm agility. We expect that firms, through their portfolio of IT applications, have different levels of internal and external electronic integration. Therefore, firms can be classified into four distinct groups, as represented in our framework (see Figure 1).

In the following section we describe the four cells of our framework, illustrate them with examples, and explain the mediating roles of knowledge exploitation, knowledge exploration, and process coupling.

2.1. The Sensing Firm: External Electronic Integration as a Sensing Enabler³

Firms with high external electronic integration (i.e., the degree to which IT applications of a firm work as a functional whole with IT applications of business partners) but with limited internal electronic integration are able to sense market changes, but they have difficulty responding to changes.

External electronic integration connects a firm with its customers, suppliers, and/or partners. IT applications that support processes such as sales, distribution, procurement, and supply chain can be categorized as external integration. These IT applications essentially enable outside-in capabilities (Wade and Hulland, 2004) and allow firms to anticipate market requirements by managing external relationships and enhancing market understanding (Day, 1994; Wade & Hulland, 2004). Research points to the importance of getting new fresh knowledge about factors affecting the firm from the environment in order to be able to make sense of environmental changes. For instance, Braunscheidel and Suresh (2009) show that firms that are well connected with their external partners survive in dynamic turbulent environments because they more easily acquire and share information and knowledge and are able to continuously evolve and improve their business processes. The evidence also suggests that firms that maintain communication channels and achieve close relationships with suppliers are able to collect information about potential environmental threats and opportunities (Hoyt, Huq, & Kreiser, 2007). Other research suggests that knowledge transfer with external partners, as enabled through mutual understanding, improves firm flexibility (Sanchez & Perez, 2005). In the study of a globally distributed information systems development team, Sarker and Sarker (2009) report that constant communication with project stakeholders enables scanning and sensing while tapping into the knowledge stocks and flow of a firm. The ability to scan firm environment is a critical element of being agile in turbulent environments as it allows firms to keep up with trends and opportunities that may change the competitive dynamics of the firm. Essentially, the evidence suggests that the ability of a firm to gain knowledge from external sources influences its ability to sense threats and opportunities in the environment.

External electronic integration improves sensing capabilities by helping firms to explore and gather new knowledge, often related to competitive activity, changes in demand, and other social, legal, and technological activities (Cho, 2006; Singh, Watson, & Watson, 2002). Two firms that create electronic linkages develop inter-firm knowledge sharing routines that allow them to provide each other with new information about their environment that they otherwise might not have shared (Malhotra et al., 2007). For example, Dow Chemicals developed an extranet that is integrated with the company's back-end ERP systems, which enables Dow's customers to place orders, check order status, obtain account information, and communicate with Dow about their needs (Chatterjee, Segars, & Watson, 2006). In addition, Dow has established ERP-to-ERP connections with its buyers and suppliers. Such connectivity improves Dow's ability to sense market trends and improve product offerings, since its customers and suppliers provide important feedback related to changes in Dow's competitive environment and their own needs. This suggests that external electronic integration increases the range of environment scanning and improves the sensing capability of the firm (Malhotra et al., 2007).

³ Although external integration might also have a positive association with a firm's responding capability, we expect that its primary influence will be on a firm's sensing capability. Hence, the focus of our paper is on the relation between external integration and sensing capability of the firm.

External electronic integration enhances knowledge exploration in three main ways. First, external electronic integration enables boundary spanning (Brown & Duguid, 1998; Carlile, 2002; Malhotra et al., 2007). Externally-oriented IT applications improve syntactic boundary spanning (Carlile, 2004; Malhotra et al., 2007) because they help to develop a common lexicon/language among partners. External integration also facilitates semantic boundary spanning because it allows the entities to develop common meanings that enable transfer of knowledge across the boundary (Carlile, 2004; Malhotra et al., 2007). Finally, external electronic integration facilitates pragmatic boundary spanning by providing a concrete means of representing different functional interests and facilitating their negotiations and transformation (Carlile, 2004). In their study of supply chain systems, Malhotra and colleagues (2007) find that external integration enables firms to explore knowledge from existing suppliers and partners by allowing them to provide suppliers with initial product design and getting feedback for improvements and adjustments. They also engage in collaborative design through common IT applications. Thus, firms that are integrated with each other are likely to share knowledge that each of them has gathered from their respective environments. The focal firm, therefore, increases the chances of appropriating new knowledge by expanding the range of knowledge domains that it accesses through new partners (Dyer & Singh, 1998).

Second, external electronic integration facilitates knowledge exploration and sensing capabilities because it facilitates the integration of different perspectives on environmental problems and opportunities, which improves managers' understanding of market trends and issues (Aranda & Molina-Fernandez, 2002). The literature on divergent thinking shows that cycles of divergent and complementary thinking culminate to convergent thinking and subsequent innovation (Leonard & Sensiper, 1998). Bringing different perspectives from multiple knowledge sources challenges the dominant mindset and improves the chances of noticing opportunities. For instance, Toyota became a market leader, not by keeping its suppliers at arms length, but by integrating information and knowledge obtained from partners, which nurtured a cycle of continuous environmental scanning (Dyer & Hatch, 2004). Without such heterogeneous insights, a firm might only perceive obvious, but sometimes suboptimal, solutions.

Third, external electronic integration allows access to intellectual capital and promotes opportunity scanning, which improves the capability to sense environmental threats and opportunities (Nonaka, 1994; Okhuysen & Eisenhardt, 2002; Powell, Koput, Smith-Doerr, & Owen-Smith, 1999). A firm that combines knowledge from its partners and customers expands the range of the environment it surveys and becomes an extended enterprise (Rai et al., 2006). For instance, Subramani (2004), in his study of supply chain management systems, depicts how such systems help in sensing. Access to retail data allows suppliers to better understand regional variations in size and color preferences. This understanding of the customers' preferences leads the supplier and the retailer to reduce the level of markdowns and improve margins on product lines and reinforces the high-end image of the supplier's products. This also allows the suppliers to plan new design collections for different geographic regions.

External electronic integration, thus, allows firms to gain and appropriate new knowledge through partnerships by giving them access to market, manufacturing, and product knowledge not otherwise accessible (von Krogh, Nonaka, & Aben, 2001). External integration also allows companies to establish new routines by rethinking old decision-making and behavioral patterns and probing into unconventional methods to understanding consumer preferences (von Krogh et al., 2001).

Firms in the "sensing" quadrant have a low ability to respond because of low internal electronic integration. Response capability depends on the mutual adjustment of organizational subunits and on the exploitation of knowledge from various subunits (Gittell & Weiss, 2004). Firms with low internal integration can find it difficult to capitalize on the knowledge sources that exist internally and cannot easily take advantage of each unit's understanding of the broader organizational environment (Ancona & Caldwell, 1992). The limited communication typically associated with low internal integration (Barki & Pinsonneault, 2005) also impairs coordination, the coupling of business processes, and mutual adjustment, as well as the ability to take advantage of different subunits' perspectives and expertise.

Airbus is an example of a “sensing” firm. Airbus often draws on its connections with its numerous partners and is known for its keen ability to sense market changes. For example, Airbus became the first company to produce and market a commercially viable fly-by-wire airliner, the A320. It was also the first manufacturer to produce a “superjumbo” passenger airliner (the A380), which appears to be becoming a flagship of the 21st century. The A380 project, however, also reveals how the lack of internal integration at Airbus affected its ability to respond to this new opportunity in a timely manner. The project was marred with major delays and cost overruns due to incompatibilities in the design of electrical harnesses in the plane’s fuselage (Sosa, Eppinger, & Rowles, 2007). It was later recognized that these problems could have been avoided had the teams involved in the design of various components communicated effectively with each other. One of the main reasons cited for the communications breakdown among the A380 teams was the lack of compatibility among the computer aided design tools they used (Sosa et al., 2007). The Airbus teams failed to communicate adequately with each other because the project planners did not think through how they integrated activities among teams. By using incompatible systems, the teams were unable to properly communicate design interface specifications during the design phase. This caused major delays in the last phases of the development of the Airbus A380. Essentially, an incompatible system hindered the teams from capitalizing on each other’s knowledge and also reduced their ability to properly link process activities. The results were only revealed in the final phases of development.

This leads to the following firm-level proposition.

Proposition A: Since external electronic integration allows firms to draw upon new knowledge sources outside of the organization, but low levels of internal electronic integration limits firms’ ability to exploit existing internal knowledge and to efficiently coordinate processes, firms in the sensing quadrant will have a high sensing capability and a low responding capability.

2.2. The Responding Firm: Internal Electronic Integration as a Responding Enabler⁴

Firms that have high internal integration (i.e., where IT applications in a firm work as a functional whole with other internal IT applications through standardized electronic interfaces) but low external integration are in a position to react and adjust to environmental changes, but they are unable to systematically detect important signals because of a lack of sufficient sensing capability.

Internal electronic integration essentially enables an inside-out capability (Day, 1994; Wade & Hulland, 2004). Firms that achieve a high level of internal integration among subunits attain greater responsiveness to threats and opportunities in their environment by improving the coordination among activities (Gattiker & Goodhue, 2005; Malhotra et al., 2007; Truman, 2000). For example, until 2002, the International Game Technology (IGT) Company, which manufactures slot machines and lottery machines, used to depend on several non-integrated information systems to manage sales, customer orders, manufacturing, and accounting (Rainer & Turban, 2009). There was no single system that would allow a manager to track a particular sales order, and the company struggled to effectively respond to customer needs. After integrating all operations through an ERP system, the company was able to attain seamless communication among its three major business functions – finance, manufacturing, and product development. The company improved response times and inventory turns, and rush orders were filled in four weeks instead of seven to eight weeks prior to the ERP. Order tracking became a painless process that allowed company executives to quickly respond to market opportunities through appropriate channeling of company resources (Rainer & Turban, 2009). Hence, internal integration improved the responding ability of the firm to market requirements.

⁴ Although internal integration might also have an effect on a firm’s sensing capability, we expect internal integration to primarily influence the firm’s responding capability. Hence, the focus of our paper is on the relation between internal integration and the responding capability of the firm.

There are two main factors that link internal electronic integration and firm responding capability: knowledge exploitation and process coupling among internal units. *Knowledge exploitation* involves transferring and creating knowledge from existing sources within the firm (Von Krogh et al., 2001). Internal electronic integration can help firms exploit knowledge and improve their responding capabilities in two main ways.

First, electronic integration serves as an important enabler of a firm's ability by standardizing communication protocols and data schemas (Barki & Pinsonneault, 2005). This standardization of communication protocols enables the development of shared meanings and the emergence of a common language among units, which forms the basis of knowledge transfer and subsequent combination from organizational units (Grant, 1996). As electronic integration standardizes organizational data and processes across different units, complex and tacit knowledge of procedures is converted into explicit knowledge. Conversion of unit-level organizational knowledge of processes into explicit knowledge eases knowledge transfer among the units (Kessler, Bierly, & Gopalakrishnan, 2000; Nonaka, 1994). Knowledge that is understood by a single unit has limited value to the organization as a whole. Thus, internal electronic integration opens up pathways for knowledge exchange and promotes knowledge exploitation among units. This allows diverse and complementary components of organizations to be more responsive to each other and to behave as a unified whole (Barki & Pinsonneault, 2005).

Second, internal electronic integration brings together different organizational units' perspectives (Gattiker & Goodhue, 2005). The scope and depth of existing knowledge expands as additional expertise from other internal units is brought in. Producing value-creating products and services in response to market threats or opportunities typically requires the application of specialized knowledge in various organizational units (Grant & Baden-Fuller, 1995). Transferring and expanding knowledge (through internal integration) is essential for responding capability, since many products and services draw upon knowledge of various internal units and are not produced by self-contained units. The exploitation of knowledge from internal units enables an efficient response to opportunities (Benner & Tushman, 2003).

Carlile (2002) shows how a CAD system, serving as a repository for supplying a common reference point of data, measures, and labels, allows for development of shared definitions of the issue that helped in cross-unit problem solving. The CAD system was implemented in the design, manufacturing and production functions of a company that manufactured on-board vapor recovery valves (OVRVs). Prior to the implementation of the CAD system, it was difficult for the engineers of the different functions to communicate their design and manufacturing concerns to each other. The new CAD system solved this problem by using standardized forms and reporting formats that allowed a shared syntax or language for the different functions to represent their knowledge. For instance, the CAD system allowed creation of assembly drawings that depicted both, the manufacturing concerns (orientation of parts, their order, and the location of problematic parts) as well as the design concerns (critical tolerances, functional specifications, and overall dimensions of the design). These standardized assembly drawings enabled the manufacturing engineers to communicate their concerns about initial design problems to the design engineers. Hence, the engineers in the different functional areas (manufacturing and design) were able to understand the other party's perspective and exploit knowledge from existing knowledge domains, which was not possible before the system was implemented. Access to knowledge about manufacturing problems through the new assembly drawings enhanced the capability of the design engineers to understand the problems in OVRV design. Thus, the CAD system acted as a boundary object that facilitated representing, learning about, and transforming knowledge from the different operational areas. The system enabled development of a common vocabulary among different functional areas and promoted cross-unit interaction and knowledge exploitation (Tsai, 2001). This enhanced their capability to respond to opportunities (Galunic & Rodan, 1998).

Internal electronic integration also enables responding capabilities because it facilitates the *coordination and coupling* of activities, i.e., the intermeshing of process activities in a way that they provide quick assistance with exception handling (Robicheaux & Coleman, 1994; Saraf et al., 2007). Internal electronic integration improves process coupling among organizational units (Saraf et al., 2007). When

firms integrate subunits, they develop standardized routines and operating procedures that allow them to coordinate processes across subunits (Saraf et al., 2007), making them responsive to opportunities. An integrated electronic infrastructure allows for reconfiguring of processes due to system modularity and standardized communication routines (Malone et al., 1999). Partners in an exchange relationship tailor their processes to each other and insure that specialized routines are adaptive to each others' requirements. In fact, research indicates that companies that achieved high levels of internal process coupling were better able to combine and use internal resources to improve flexibility in product development (Antonio, Richard, & Tang, 2009). In a study of manufacturing firms, Inter-departmental coordination was found to be a key enabler of firms' coordinated responses to environmental changes (Braunscheidel & Suresh, 2009). Research shows that by streamlining process activities, firms improve internal and cross-functional communications, are better able to solve potential problems early in the manufacturing and development processes, and are quicker to capture opportunities (Mishra & Shah, 2009). Taken together, research shows that firms with tight internal coupling of their processes are able to better synchronize and adapt process activities and, thus, are more agile.

IT seems to be a key factor in coupling business processes and improving response capabilities. Setia, Sambamurthy, & Closs (2008) found that firms using IT to couple their processes easily reconfigured their processes, rescheduled jobs, and reassigned resources to adjust to external demands. Tight process coupling was also found to facilitate concurrent execution of business activities and coordination among internal units, and, hence, enabled firm responding capability (Coronado, Sarhadi, & Millar, 2002). Research shows that enterprise systems enable coupling of process activities in a way that allows units to seamlessly coordinate their activities such as product design, material procurement, plant-floor operational control, and shipping processes (Heim & Peng, 2010). This process coupling among firm units enables efficient customization of process activities, which affords responsiveness to market opportunities (Heim & Peng, 2010). Internal electronic integration allows unfettered access to information and knowledge across subunits and, thus, it enables the coupling of firm processes. Internal electronic integration creates both syntactic (i.e., developing a common/shared language between partners engaged in an exchange) and semantic integration (i.e., developing common meanings that help overcome any interpretive differences that may exist between partners involved in an exchange), which facilitate the sharing of operational data and the intermeshing of processes across the entire value chain (Malhotra et al., 2007; Saraf et al., 2007; Yang & Papazoglou, 2000). For instance, internal integration allows a subunit to coordinate flow of inventory and orders with other subunits (Gattiker & Goodhue, 2005). Thus, changes in one subunit are noticed across all connected subunits and allow incorporating corrective measures so that processes such as manufacturing, materials handling, and the like remain well coordinated and uninterrupted. Enterprise systems that span subunit boundaries are an example of this coordination that leads to higher process coupling in the firm. This increased coupling among business units allows the manufacturing process within the firm to be adaptive to changes in demand, process design, process technology, and material supply (Swafford, Ghosh, & Murthy, 2006). A study of manufacturing plants found that integration through IT allowed firms to efficiently link business processes together due to improved visibility and information flow (Bharadwaj, Bharadwaj, & Bendoly, 2007). Thus, a customer order entered at one operational unit can immediately start processing in all other related areas. It can trigger changes in production plans, inventory stocks as well as purchase orders for suppliers (Bharadwaj et al., 2007).

In sum, internal electronic integration enables exploitation of knowledge from internal units and brings diverse organizational units together such that they are responsive to each other's needs and behave as a unified whole. The diverse but complementary knowledge pools help firms assemble a quick, coordinated response to opportunities and threats. Further, internal electronic integration provides opportunities for subunits to seamlessly couple process activities. It allows the development of specialized routines for interaction among organizational units and also creates room for flexibility to quickly solve unforeseen events. This increased process coupling allows the units to be responsive to their environment.

While firms in this quadrant can respond to market changes with speed, their ability to sense such changes is limited because of low external electronic integration. Recall that the key activities involved in knowledge exploration, which is essential to the sensing capability, involve gaining new

knowledge mainly through external partners and creating new knowledge by developing new data and seeking new information around a loose idea or vision. The literature on the relational view of the firm (Dyer & Singh, 1998) suggests that firms operating in isolation have a limited ability to access new knowledge and new sources of creativity. Lack of external integration insulates firms from knowledge that exists beyond their boundaries (Burt, 1992). Firms that are oblivious toward making external connections overlook emerging areas of knowledge related to technology, markets, and processes (Goerzen, 2007). Thus, firms are unable to take advantage of new knowledge domains due to a stunted ability to recognize them (Benner & Tushman, 2003). Henderson and Clark (1990) studied the photolithography equipment industry and found that lack of external communication linkages constrained the ability of firms to recognize new trends in markets. Manufacturers working in isolation missed chances to gain knowledge regarding the evolving market, new opportunities, new designs, and emerging customer groups and technologies.

Stryker Osteosynthesis, which provides reconstructive, trauma, and spinal products and offers cost-effective solutions for orthopedic diseases through state-of-the-art products (Zueger & Green, 2011), illustrates this cell well. Stryker recently installed an ERP system that integrates its three production sites and a distribution center and seamlessly coordinates their operations. This internal integration allows the distribution center to obtain complete and accurate company-wide financial and operational information. The integration also enables the flow of material and products across the three production sites (Zueger & Green, 2011). However, without external connections, Stryker has had a limited capability to match the demand of its customers with its operations. The lack of external linkages with customers and suppliers created a bullwhip effect and threatened Stryker's position in the market. Without the end-to-end integration of its entire supply chain, Stryker struggled to ensure that inventory was neither in excess nor too low. Essentially, the internal integration facilitated Stryker's responding capability, but without external integration, Stryker lacked the ability to sense market change. Stryker recently corrected this problem when it electronically integrated its suppliers and customers.

Proposition B: Since internal electronic integration allows firms to exploit knowledge of internal organizational units and to be responsive to each other and behave as a unified whole, but low levels of external electronic integration limit firms' ability to sense market trends, firms in the Responding quadrant will have a low sensing capability and a high responding capability.

2.3. The Agile Firm

Firms with high degrees of external and internal electronic integration are able to sense and respond to market changes with speed and dexterity. High external integration affords unfettered access to information across organizational boundaries and allows firms to capture insights from partners that are seamlessly connected (Wang & Wei, 2007). The focal firm essentially becomes an extended enterprise that expands the range of its environment that it scans directly or through external partners (Malhotra et al., 2007). By accessing several sources of new knowledge (i.e., partners' knowledge), the firm attains a greater information-processing capability, which increases its knowledge exploration and environmental sensing. By obtaining information from many different sources, firms are able to sense changes in the environment (Beal, 2000; Hambrick, 1982), learn about customers and competitors, and recognize external opportunities and threats (Cho, 2006). Similarly, as discussed earlier, a high degree of internal integration allows internal organizational units to work in tandem, as a unified whole, and to be responsive to each other (Barki & Pinsonneault, 2005).

Enterprise systems that span subunit boundaries as well as organizational boundaries are good examples of the combination of these two types of integration (Swafford et al., 2006). The information flow allows firms to gain knowledge from their environments and sense impending change. Similarly, the coupling and close coordination enabled by internal integration facilitates responding ability.

An example of an agile firm is IBM, which has successfully transformed itself from a technology company to an on-demand, broad-based solutions provider (Harreld, O'Reilly, & Tushman, 2007). It has become a "globally integrated enterprise" that has streamlined internal and external operations, a crucial

factor of which is IBM's integrated information system (Strikwerda & Stoelhorst, 2009). Internal functions – such as finance, HR, legal, communications, and sales – share data that enable managers to be aware of orders, leads, and other customer information. This facilitates cooperation between managers and also allows them to see their contribution to IBM's overall profits (Strikwerda & Stoelhorst, 2009). This streamlining of internal processes allows IBM's units to be responsive to each other by sharing information. In addition, IBM created its "Inside IBM" initiative that allows the integration of its processes with customers over the Internet (Massey, Montoya-Weiss, & Holcom, 2001). As soon as a customer begins a session at this portal, an applet triggers a diagnostic device on the customer's end enabling the IBM human expert to quickly diagnose the client's vital information. This information, matched with already saved customer profiles, enables IBM to quickly pinpoint customers' points of pain and recommend solutions. Additionally, sophisticated data-mining techniques are used to predict and proactively solve potential data, hardware, and software problems. Moreover, customer profiles and current diagnostic information enable IBM to position its products and services in a much more effective way by sensing the impending needs of the customers.

Another example of an agile company is B&Q China (IBM, 2009). It is one of the top three global decorations and building materials groups, headquartered in Shanghai, China. In the past B&Q relied on paper-based notes to keep track of all operations (project requirements, status, sales and value) as well as to follow-up with potential customers). Staff maintained diaries to make follow-up calls to potential customers, and all sales data was collected and collated manually. This process took several months, and often, market opportunities were missed due to the inefficiency of the operations. B&Q then decided to implement an ERP system along with a CRM system (IBM, 2009). This allowed B&Q to manage all customer and project data electronically, resulting in an enhanced ability to identify the right time to follow up with customers and maximize sales opportunities. The ERP system, combined with the CRM system, allows B&Q to efficiently track and respond to demand for its products and monitor trends in the industry.

To summarize, a firm with high external electronic integration and high internal electronic integration has high sensing and high responding capabilities. This effect unfolds through the mediating effects of knowledge exploration, knowledge exploitation, and process coupling. Thus, we make the following proposition:

Proposition C: Since external electronic integration allows firms to draw upon new knowledge sources outside of the organization, and internal electronic integration allows firms to exploit knowledge of organizational units and make them responsive to each other and behave as a unified whole, firms in the Agile quadrant will have high levels of sensing and responding capabilities.

2.4. The Stagnant Firm

Firms that have low external electronic integration and low internal electronic integration fall in the Stagnant quadrant. Firms with low external integration are typically limited in their ability to explore knowledge among units and, therefore, have limited capabilities to sense opportunities and threats in their environment. Firms that have low integration with outside members are essentially maintaining arms-length relationships with their partners. That is, they are not committing to long-term interactions with their partners and are losing the opportunity to promote trust in the relationship. Partners in an exchange relationship marked by low external integration are wary of readily sharing important knowledge (Dyer & Hatch, 2004; Dyer & Singh, 1998). This has the effect of reducing a firm's ability to probe and seek out new knowledge from partners. Thus, the low external integration with members outside of the organizational boundaries reduces the knowledge exploration ability of the firm.

Recall that knowledge exploration increases the probability that a firm comes across new knowledge pools because it can access a wider array of heterogeneous knowledge regarding opportunities or threats to the firm (Rodan & Galunic, 2004). Low knowledge exploration restrains a firm's ability to sense market opportunities and threats because it limits its access to different and complementary

perspectives to pore over impending changes in the environment. This simplifies the breadth and depth of environmental scanning and can lead to an overly simplistic view of the environment (Miller, 1992; Miller, 1993; Miller & Chen, 1996). Therefore, firms with low external electronic integration have a limited ability to sense changes in their environment.

Firms with low internal electronic integration have a limited ability to respond to opportunities and threats in their environment. The low internal integration limits the ability of subunits within a firm to behave as a unified whole and, thus, limits the firm's ability to respond to market variations. Low levels of internal integration are characterized by specialized domain-specific skills and knowledge that is difficult to share and integrate across units (Hitt, Hoskisson, & Nixon, 1993).

Some companies have a large number of disparate systems that have been developed, and sometimes incrementally modified, over time to respond to the unique needs of particular subunits (Reddy, 2006). These legacy systems are typically crucial to the ongoing operations of the firm, but they are quite inflexible, rigid, and loosely coupled (Reddy, 2006). Hence, there is little to no integration among these disparate systems, and visibility across functions as well as organizational boundaries is non-existent. For instance, inventory management may continue to focus on developing a storage schema that is most efficient for maximizing warehouse space utilization, while manufacturing may be heavily focused on developing ways to be most effective in accessing parts from the warehouse. The increased focus on subunit level goals may limit the ability of subunits to share their specialized domain knowledge and achieve common goals. Hence, limited internal electronic integration impairs a firm's ability to exploit specialized knowledge of internal units and leads to a low responding capability.

Moreover, a low level of internal integration is also likely to hinder a firm's responding capability by limiting process coupling among activities. Low internal electronic integration is characterized by limited syntactic and semantic integration in organizational data that is distributed across different units in different formats. This greatly reduces the linkage among organizational subunits and hinders seamless intermeshing of process activities (Reddy, 2006; Wang & Wei, 2007). Hence, organizational subunits have a limited ability to quickly adapt process activities to variances, and the overall organizational response to market opportunities and threats is sluggish (Barki & Pinsonneault, 2005; Reddy, 2006; Saraf et al., 2007).

An example of a stagnant firm is A&P (officially known as the Great Atlantic & Pacific Tea Co.) before it implemented an ERP system. In the 1990s the company faced severe competition from agile grocery chains such as WalMart, Krogers, and Safeway. In its prime (around the year 1959), the 151-year-old company's revenues were second only to that of General Motors. However, the company ran on cobbled-together legacy information systems, written in custom code using COBOL, and not updated in 12 to 15 years (Patton, 2001). Most of the hardware consisted of terminals hooked to mainframes in two central locations. Unlike the competition, A&P's legacy systems were extremely antiquated and provided no way of analyzing data from customers or suppliers, and internal functions were also disjointed (Patton, 2001; Reddy, 2006). The lack of external electronic integration with customers and suppliers put A&P at a disadvantage by reducing its ability to understand new trends in the market. Hence, the company's sensing capability was quite limited. Moreover, due to lack of integration among internal units, A&P lacked the ability to quickly respond to opportunities. Changes in product selections were often brought in late, while customer tastes changed. The grocer often followed the market leaders and was forced to play catch-up with the competition. In sum, due to absence of integration among systems, the firm severely lacked the ability to sense changes in market requirements and was unable to respond to change efficiently.

Proposition D: Since a low level of external electronic integration limits a firm's ability to explore new knowledge in the environment, and a low level of internal electronic integration limits a firm's ability to share specialized knowledge among business units and to couple business processes, firms in the Stagant quadrant will have low levels of sensing and responding capabilities.

3. Discussion

IS research provides significant insights into how IT affects firm agility (Overby et al., 2006, Sambamurthy et al., 2003; Tallon & Pinsonneault, 2011). We now need to understand how specific IT characteristics (such as integration, flexibility, and so forth) affect the two key capabilities of agility: sensing and responding. It is also important to better understand the role of mediating variables, such as firm knowledge and process coupling. This paper extends the literature on the topic by analyzing how two key dimensions of IT, internal and external integration, affect the two capabilities of agility (sensing, responding). We also looked at how knowledge and process variables mediate the IT-agility relationship. By doing so, we were able to explain how each electronic type of electronic integration affects the sensing and responding capabilities of the firm. We argued that internal integration has a primary enabling effect on the responding component of firm agility through the mediating role of knowledge exploitation and process coupling. External integration has a primary enabling effect on the sensing element of firm agility through the mediating role of knowledge exploration.

Our framework helps firms understand in which agility quadrant they reside. In addition, the framework can also be helpful for understanding how a firm evolves from one situation to another. Essentially, there are three possible paths for a stagnant firm to become agile. First, a stagnant firm can move toward agility by achieving internal integration. This internal integration improves the firm's responsiveness and allows it to coordinate internal activities. This places the firm in the responding firm quadrant. Further improvements in external integration will enable the move toward the agile firm quadrant. This is the most likely path because it starts with improving the organization's infrastructure and then making improvements across organizational boundaries (Venkatraman, 1991). In order to gain agility, it is important to first integrate internal units in a way that they become responsive to each other's needs and start behaving as a unified whole (Barki & Pinsonneault, 2005). Once internal integration is achieved, external integration complements organizational responsiveness by enabling access to greater insights from outside partners.

DDM, a Canadian plastics manufacturing firm, became responsive to a highly competitive environment by following this path (Saeed, Malhotra, & Grover, 2005). DDM already had an enterprise system in place that allowed coordination among internal units. What DDM lacked was connections with external suppliers. The company introduced an Internet-based system called SupplyWEB that allowed integration with external partners, which enabled it to lower its inventory and reduce uncertainty in its environment by gaining greater visibility across organizational boundaries.

Another potential path toward agility is one where a firm achieves external integration first. The external integration improves the sensing capability of the firm and places it in the sensing firm quadrant. This path, however, is much more uncertain and is more risky. Without first integrating internal resources, the organization might find itself unable to quickly respond to opportunities. Challenges associated with this path are rife in the EDI literature (Curtin, Kauffman, & Riggins, 2007; Riggins & Mukhopadhyay, 1994). For instance, research shows that firms that chose to implement EDI with partners (external integration) without having internal integration of processes gained limited benefits and often did not see any performance improvements (Riggins & Mukhopadhyay, 1994). More recent research on RFID-enabled supply chains has also confirmed that integration with external partners without the capability to seamlessly handle information among internal departments results in failure to see performance gains (Asif & Mandviwalla, 2005).

Finally, another path toward the agile-firm quadrant is to attain both internal and external integration at the same time. This is a difficult strategy because it involves simultaneously handling several organizational variables (processes, units, technologies, cultures) and entails important implementation challenges and barriers (Barki & Pinsonneault, 2005). However, if achieved, it can result in improved agility over competitors. Harris Tea, which has an impressive 160-year history of procuring and blending teas, is the largest blender and packer of private label teas in North America. As its business grew, Harris Tea struggled with maintaining visibility and coordination among internal units and with partners and customers, which were critical for inventory operations and customer support. To solve these problems, Harris Tea implemented an enterprise system that integrated internal operations as well as

external partners in a seamless fashion. Now customers can submit orders in any format, and they are translated into user-defined formats and entered into Harris' warehouse management and ERP systems. All internal units can immediately view orders and start adjusting activities to meet the demand. Moreover, insights from customers can help Harris Tea appropriately plan by adjusting when to produce, store, and ship goods (Ackerman, 2007).

4. Contribution

Our paper contributes to research and practice in three important ways. First, we focus on one specific characteristic of IT and its role on the individual capabilities of sensing and responding. Research suggests that rather than studying the enabling factors of agility, in general, it is more fruitful to study the enabling factors of the individual elements of sensing and responding (Overby et al., 2006). We follow this route and investigate how certain characteristics of IT, rather than the broad IT construct, affect the individual elements of sensing and responding. Although there could be several important IT characteristics of interest (such as scalability, reconfigurability, and so forth), our particular focus is on the integration enabled by IT. The impact of IT applications on firm agility depends on the type of integration they support. We present a fine-grained understanding of this relationship by conceptualizing the relation between two types of integration – internal and external – and the two elements of firm agility: sensing and responding. Second, our paper provides a better understanding of how electronic integration might affect outcomes other than efficiency-oriented ones, such as number of policies sold (Venkatraman & Zaheer, 1990), operating costs, and shipment errors (Srinivasan, Kekre, & Mukhopadhyay, 1994), and different process efficiency measures (Barki & Pinsonneault, 2005). However, research on how IT affects firm ability to be responsive to the environment is limited. This paper fills this important gap.

Finally, our paper contributes to practice by providing an explanation of how IT can affect firm agility. Numerous firms pursue electronic integration and firm agility in parallel without clearly understanding how they are related and how they can create synergies between these two goals. Our paper can help managers better understand the differential and complementary impacts of the two types of electronic integration on firm agility and may forewarn them of the possible pitfall of focusing too much on any one type of electronic integration.

5. Future Research

Research is needed to empirically test the proposed framework and propositions. To test the framework, the first step should be to study firms that fall in each of the quadrants of the framework through in-depth case studies. Case selection should favor both theoretical and literal replications (Yin, 2009), and thus, allow for maximum variation as well as comparison across sites (Gilgun, 1995). Case studies should focus on the similarities and variations of two characteristics of the firm: the type of integration (internal or external) afforded by the IT applications and the agility outcome. Multiple respondents will be required at each site, including senior IT (CIO or CTO to assess the level of electronic integration fostered by the IT application portfolio) and business managers (VP, or other operational C-level to assess the degree of agility gained at the firm level). Special focus should be on understanding how the firm fares with regard to the overall sensing and responding capabilities of competing firms.

To complement the organization-level analysis, process-level analyses should also be conducted to gain a detailed understanding of the role or knowledge and process coupling in mediating the IT-agility relationship. Data should be analyzed in two stages: process-level, and within-case analysis and cross-case analysis (Eisenhardt, 1989). Since the topic is relatively new and under-researched, the analytic induction approach might provide interesting insights (Gilgun, 1995). In analytic induction, researchers have two goals. First, they try to test propositions developed prior to entering the data collection phase (Gilgun, 1995). These propositions are often general approximations developed from "hunches, assumptions, careful examination of research and theory or combinations" (Gilgun, 1995, p. 268-269). The second objective is to use the data and fieldwork to uncover unexpected patterns and relationships to further refine the framework. In the inductive part of the exploratory case studies, particular attention should be given to uncovering additional and complementary mediating factors. For instance, it is

possible that some factors sometimes associated with IT such as the routinization of processes, short-term goals, and the narrowing of strategic repertoire might act as barriers to agility (Tallon & Pinsonneault, 2011). This exploratory empirical work should be followed with a survey of a broader sample drawn from companies in several industries. The effects of the mediating variables should be tested using mediation analysis techniques, such as nested model analysis and mediation analysis (Chin, Marcolin, & Newsted, 2003; Subramani, 2004).

Moreover, future research should also assess the typology of different combinations of the two types of integration. In this exploratory paper we focus on the four situations that arise from combining the extremes of the two types of integration. It is very likely that firms might have integration levels that are not at the two ends of the two continuums (internal and external EI), but rather somewhere in the middle of these continuums. Finally, future research should also assess the impact of some contingent factors on the IT-agility relationship. For instance, firm size might be an important moderator⁵. For example, smaller firms might not get significant new insights from internal electronic integration and knowledge exploitation, and most new knowledge is likely to come from external exploration. In large multinational firms, internal electronic integration and knowledge exploitation might bring significant insights. Because of their breadth and diversity (e.g., a multitude of product lines, business units in different countries, different cultures and ways of doing things), large firms are likely to have many disparate viewpoints and perspectives internally. Environment uncertainty might be another contingent factor. Uncertainty can arise from various sources, such as market turbulence, competitive intensity or technological change (Jap, 2001; Jaworski & Kohli, 1993). All these factors have an inherent ability to change the environmental conditions of the firm, as each might have different effects on the IT-agility relationship. Hence, it is important that future research assesses how these factors affect the relationship between IT and agility.

By analyzing the relationship between IT and firm agility through an electronic integration perspective, this paper provides a new theoretical foundation to study this phenomenon. While we provide some answers about the impact of IT on firm agility, our framework raises many other questions and, as such, we hope that it will stimulate and guide further research on this important topic.

⁵ We thank one reviewer for suggesting this idea.

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Appendices

Appendix A.

| Exhibit A-1. Studies Examining Knowledge Variables in the Agility Literature | | | |
|---|---|--|---|
| Reference | Focus | Knowledge variable | Findings |
| Externally-oriented (Knowledge Exploration) | | | |
| Devaraj, Krajewski, and Wei (2007) (sample: 120 manufacturing firms) | Assess the impact of e-business technologies on operational performance. | Knowledge exchange (with suppliers and customers) | Production Information Integration with suppliers, as enabled by e-business capabilities, plays an important role in enabling flexibility of firm. |
| Hoyt et al. (2007) (sample: 66 respondents from auto, instrumentation and semiconductor industries) | Investigate enablers of organizational responsiveness | Environmental Scanning | Enterprise systems that enable standardized flow of information are found to play a critical role in enabling firms to gather knowledge and scan their environments. |
| Braunscheidel and Suresh (2009) (sample: 218 manufacturing firms) | Investigates the impact of two antecedents, market orientation and learning orientation and other related organizational practices, on augmenting the supply chain agility of a firm. | Learning Orientation | Learning orientation promotes knowledge flow among organizational units which improves overall firm flexibility. |
| Sarker and Sarker (2009) (case-study of an ISD firm using grounded theory methodology) | Develop an empirically grounded framework of agility in distributed ISD settings and identifying some actionable tactics for enhancing agility within such settings. | Communication with organizational members and outside stakeholders. | Knowledge flows among organizational members through constant communication and interaction is found to be an important enabler of agility. |
| Internally-oriented (Knowledge Exploitation) | | | |
| Gunasekaran, Lai, and Cheng (2008) (case-analysis of 5 firms from secondary source data) | Develop a framework for a responsive supply chain based on the strategies, methods, and techniques of agility and supply chain management | Knowledge provided to organizational members | Collaborative IT systems can be used to promote innovation, training, and education and employees can be provided with pertinent information required for solving problems in a rapid manner. |
| Fink and Neumann (2009) (sample: 293 managers) | Investigate the business value of IT infrastructure of a firm. | Knowledge of organizational processes | Knowledge of business processes of other functions is an important enabler of flexibility. |

Appendix B.

Exhibit B-1. Studies Examining Process Variables in the Agility Literature

| Study | Focus | Process Variable | Findings |
|---|---|--|--|
| Process Coupling, Agility | | | |
| Golann (2006) (sample: case-study of 6 manufacturing firms) | How internal process management affects the responsiveness of firms. | Process Coordination | Process coordination among internal units improves responsiveness and flexibility to market requirements. |
| Antonio et al. (2009) (sample: 251 manufacturing firms) | Investigate the individual and interaction effects of internal integration and product modularity. | Process Coupling (enabled through integration) | Process coupling improves communication and coordination across functional units, which, in turn, enables flexibility. |
| Braunscheidel and Suresh (2009) (sample: 218 manufacturing firms) | Investigate the impact of two antecedents, market orientation and learning orientation, and other related organizational practices. | Inter-department process coordination | Inter-departmental coordination leads to a connected and coordinated response to market opportunities and threats. |
| Mishra and Shah (2009) (sample: 189 manufacturing plants) | Examine the role of collaborative competence on project and market performance. | Interfunctional process coordination | Interfunctional coordination leads to a higher ability to respond to opportunities. |
| IS, Process Coupling, Agility | | | |
| Coronado et al. (2002) (sample: case studies of 14 manufacturing firms) | Explore the role of IS in enabling agility. | Process coupling (through concurrent execution of process activities) | Concurrent execution of business activities enables agility in firms. |
| Setia et al. (2008) (two case-studies of planning and scheduling system implementations) | Develop a framework for organizational value creation from agile IT applications. | Process Assimilation | Through process assimilation, firms achieve coordination in processes, which enables agility. |
| Heim and Peng (2010) (sample: 238 manufacturing plants) | Examine the impact of IT on the structure, practices and performance of plants | Process integration | Coupling and coordination of process activities (through IT) enables flexibility at the plant level |

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