TITLE:

The Effect of Internal and External Electronic Integration on Business Unit Agility

Salman Nazir
Information Systems Department
Desautels Faculty of Management
McGill University, Montreal

September 30, 2014

A thesis submitted to McGill University in partial fulfillment of the requirements of the degree of Doctor of Philosophy

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Acknowledgements

I would like to acknowledge the help and support of several people who helped me complete my dissertation. First, I am immensely grateful to my supervisor, Alain Pinsonneault, for his continuous, unwavering, selfless support that he provided throughout this journey. He always pushed me to do my best and always provided extremely useful feedback that improved my work. Alain has this wonderful ability to always know which way to take his students' work so that it can be successfully completed and eventually published. I have learned a great deal from Alain for which I feel deeply indebted to him.

I wish to thank my committee members, Dr. Genevieve Bassellier and Dr. Anne Beaudry, who were always there to provide useful feedback about my work. The support that I have received from Genevieve and Anne has always helped avoid major pitfalls in my work and has given me the opportunity to my polish my skills as a researcher. I am extremely grateful for your guidance and support.

I would also like to thank all my PhD colleagues who were part of my support network at one time or another. I would especially like to thank Kyung, Momin, Yasser, Saeed, Shamel, Moataz, and Jing for their friendship and support. You guys always helped me when I needed your support. I hope we can find more opportunities to work together in the future.

Finally, and most importantly, I would like thank my family for their unrelenting love and support. I can't thank enough my lovely wife, Amna, who was my pillar of support at every nook and turn and dead end of this journey. I know I would not have completed this difficult journey without her unrelenting love and continuous support and I thank her for being by my side all the time and supporting me in all my endeavors. I would also like to thank my two lovely daughters, Haya and Yusra. Finding time to play with them always energized me mentally and always took out the stress of the PhD journey. Although working on my PhD often meant fewer trips to the park, I am looking forward to making up for this lost time with them. I would also like to thank my parents for their prayers and support. I could not have made it to this point without their love, prayers and support at every point in my life.

Contribution of Authors

Salman Nazir was the primary author of this dissertation. Alain Pinsonneault acted a secondary author. The main contribution of the primary author was to write the thesis in its entirety. The main contribution of the secondary author was to provide guidance to the primary author. Alain Pinsonneault also provided useful feedback to the primary author about how to improve the structure and content of the thesis.

Abstract: *Agility - the capability of organizations to sense and respond to market opportunities and threats with speed and surprise - is quickly becoming an essential element for companies to effectively compete in hypercompetitive environments. At the same time, firms are using applications that enable close integration among organizational units. Current environment necessitates that firms pursue agility as well as tight integration. However, we still do not understand how integration affects agility. Although the literature suggests that integration enables digital options that facilitate agility, it is not clear what specifically those digital options are and how do they inform the integration-agility relation. Using coordination theory, this thesis argues that integration enables coordination among internal functions of a business unit and with external partners which facilitates business unit agility. Specifically, we argue that integration allows advanced structuring through process coupling and dynamic adjustment through knowledge flow which, in turn, enable the two agility capabilities of sensing and responding. This thesis contributes by opening up the black-box of the mediating variables that inform the integration-agility relation. We argue that the mediating variables of knowledge exploitation, knowledge exploration, and internal and external process coupling play a crucial role in this relation. Overall, this thesis contributes to the integration-agility relation by answering the following questions: (1) what is the effect of internal and external electronic integration on the sensing and responding capabilities of business units? (2) what is the role of knowledge leveraging and process coupling constructs in the relation between electronic integration and sensing and responding capabilities of business units? The model is tested with 303 business managers responsible for handling business unit operations of manufacturing organizations. Support was found for nine out of ten hypotheses which primarily argue that integration within business units and with outside partners leads to business units' increased* *capability to have advanced structuring internally and externally of the value chain. Moreover, they lead to increased capability to have dynamic adjustment within and outside the value chain. Both, advanced structuring and dynamic adjustment, lead to higher capability to sense change in the business environment and respond to it with agility.*

***Résumé** : Agilité - la capacité des organisations à déceler et à répondre aux opportunités commerciales et aux menaces du marché avec rapidité et surprise – est devenue rapidement un élément essentiel pour les entreprises qui évoluent dans des environnements hyper compétitifs. En même temps, les entreprises utilisent des technologies de l'information qui permettent une intégration étroite des unités et des processus de l'organisation. Cependant, nous ne comprenons toujours pas comment l'intégration influe sur l'agilité. Bien que la littérature suggère que l'intégration permette des options numériques qui facilitent l'agilité, il n'est pas clair à savoir quelles sont précisément ces options numériques et comment elles orientent la relation entre l'intégration et l'agilité. En utilisant la théorie de la coordination, cette thèse soutient que l'intégration permet la coordination entre les fonctions internes d'une unité d'affaires et avec des partenaires externes, ce qui facilite l'agilité de l'unité d'affaires. Plus précisément, nous soutenons que l'intégration permet de coupler les processus et favorise l'ajustement dynamique via la gestion des connaissances qui, à leur tour, facilitent les deux fonctionnalités de l'agilité : la détection et la capacité de réponse. Cette thèse contribue à ouvrir « la boîte noire » des variables médiatrices qui influencent la relation entre l'intégration et l'agilité. Nous soutenons que les variables médiatrices de l'exploitation et de l'exploitation des connaissances et du couplage des processus internes et externes jouent un rôle crucial dans cette relation. Cette thèse répond aux questions suivantes : (1) quel est l'effet de l'intégration électronique interne et* *externe sur les capacités de détection et de réponse des unités commerciales? (2) quel est le rôle que la gestions des connaissances et le couplage des processus d'affaires jouent dans la relation entre l'intégration électronique et les capacités de détection et de réponse des unités commerciales? Le modèle a été testé auprès de 303 gestionnaires d'entreprises manufacturières. Les résultats supportent neuf des dix hypothèses qui soutenaient essentiellement que l'intégration au sein des unités opérationnelles et avec des partenaires externes augmentent l'agilité organisationnelle.*

CHAPTER ONE

INTRODUCTION

The firm environment is becoming increasingly competitive and companies must consistently sense opportunities and threats and respond to them with speed and surprise in order to be ahead of the competition (D'Aveni, 1994; Goldman et al., 1995). With the onset of intense competition, firms cannot simply rely on efficiency in operations but rather have to continuously redefine and reconfigure their processes, products and services. The success of organizations in such exceedingly turbulent environments is highly dependent on the nimbleness of their processes (Overby et al., 2006; Sambamurthy et al., 2003). This is the description of firms that are agile. Agility, at the firm level, is defined as the capability of firms to sense and respond to opportunities and threats with speed and surprise (Dove, 2001; Lu and Ramamurthy, 2012; Overby et al., 2006; Sambamurthy et al., 2003). *At the business unit level, agility is defined as the capability to sense change and adapt a business unit to respond to change with speed and surprise* (Raschke, 2010). Essentially, agility is a capability that is composed of sensing and responding capabilities (Overby et al., 2006). Sensing is the capability to detect changes and developments in the environment external to the business unit (such as the customer environment, market environment, competitor environment). Responding is the capability to react to changes in demand, new product development, change in product mix, product pricing, market expansion, and change in process capabilities.

Although sensing and responding are not new concepts, their importance is being realized more recently amid intense time-to-market pressures (Dove, 2001; Overby et al., 2006; Lu and

Ramamurthy, 2011). Environmental demands require that firm units redefine their value creation and competitive performance by bringing together resources such as assets, knowledge, partnerships, and expertise from within and outside of the firm boundaries (D'Aveni, 1994; Dove, 2001; Goldman et al., 1995; Overby et al., 2006; Sambamurthy et al., 2003).

In addition to sensing and responding capabilities, firms are also hard pressed to attain internal electronic integration among the various functions of the business unit and external electronic integration with business partners in order to streamline processes, maintain constant communications with customers and partners, and attain unfettered access to information across value chains (Barki and Pinsonneault, 2005). *Electronic Integration is the extent to which IS applications of a unit work as a functional whole in conjunction with the IS applications of other internal and external units* (Saraf et al., 2007). Although internal and external electronic integration among units and the sensing and responding capabilities of these units have become two important goals, our understanding of how the former affects the latter is not clear.

1.1. The Relation between Electronic Integration and Sensing and Responding Capabilities

The literature on agility has mainly focused on conceptual issues and the benefits of sensing and responding (Overby et al., 2006; Sambamurthy et al., 2003; Setia et al., 2008). The literature that has investigated the effect of internal and external integration on agility primarily argues for a positive relationship between electronic integration and agility (e.g. Goodhue et al., 2009; Power et al., 2001). This literature reports that internal and external electronic integration, through the use of intra-organizational and inter-organizational information systems, improves inter-departmental cooperation and allows tight coordination of activities. This allows organizational units to operate as a functional whole that is characterized by seamless coordination and information visibility which translates to agility in the business unit (Narasimhan and Das, 1999; Putnik and Sluga, 2007). However, some research has also argued that there is no significant relationship between internal and external integration and agility (e.g. Booth et al., 2000; Mondragon et al., 2004; Vemuri and Palvia, 2006; Wybrow and MacDonald, 1996). This research suggests that integration attained through inter-organizational and intra-organizational systems does not improve agility of firms and that such integration does not make firms any more responsive to market changes. The primary argument is that internal and external electronic integration achieved through enterprise systems is not sufficient for any agility benefits at the firm and supply chain levels (Booth et al., 2000; Dasgupta et al., 1999; Mondragon et al., 2004; Vemuri and Palvia, 2006; Wieder et al., 2006). We do not aim to solve this contradiction in the literature. Instead, our focus is only the literature that suggests a positive link. We believe we do not understand the relationship primarily because the studies reporting a positive effect either have low explanatory power or are using case study data which is not generalizable. These shortcomings of the literature make a weak case for a positive link and indicate that we do not clearly understand how internal and external integration affect agility. Research also argues that the integration-agility relation is, in fact, mediated by important process and knowledge mechanisms (Gunasekaran et al., 2008; Moitra and Ganesh, 2005; Putnik and Sluga, 2007). Apart from the few case studies, this mediating role of the knowledge and process constructs has primarily remained unexplored.

This thesis expands our understanding of the integration-agility relation by investigating the mediating role of knowledge and process constructs. IT-enabled integration creates digital options through knowledge and process constructs (Overby et al., 2006; Sambamurthy et al., 2003). It allows firm units to seamlessly access information that is privileged, broad ranging and of high quality, and thus enables firm units to quickly perceive and respond to change (Goodhue et al., 2009; Malhotra et al., 2007; Rai et al., 2006). Moreover, electronic integration also facilitates the coordination of process activities, both within a firm and with its business partners and customers (Barki and Pinsonneault, 2005; Lyytinen and Rose, 2006; Sarker and Sarker, 2009; Setia et al., 2008). Thus, we expect the two factors – how knowledge is utilized and how processes are coordinated – to play an important mediating role in the relation between electronic integration and business unit agility (Overby et al., 2006). This is also consistent with the coordination theory of the firm, which highlights the synchronization of complementary firm resources (such as specialized knowledge and process capabilities) that partners bring to bear (Dyer and Singh, 1998; Malone and Crowston, 1990; Saraf et al., 2007). Coordination theory suggests that coordination among units can be achieved through two mechanisms: advanced structuring and dynamic adjustment. Advanced structuring refers to the standardization of processes done up front to coordinate process activities such that they become synchronized with each other and responsive to the environment (Gosain et al., 2005). Dynamic adjustment refers to the intensified exchange of information and knowledge to cope with impending changes in the environment (Gosain et al., 2005). We expect that process coupling allows for advanced structuring while knowledge leveraging enables dynamic adjustment.

The integration-agility literature also has limitations related to the conceptualization of the agility construct. While the importance of conceptualizing agility appropriately has been recognized in the literature, studies have limited themselves to the responding capability of agility. Previous studies have used the responding construct as a proxy for the entire agility construct (e.g. Power et al., 2001; Silveira and Cagliano, 2006; Swafford et al., 2008; Wang and Wei, 2007) and do not incorporate the sensing element. Recognizing this essential element and assessing the effects on both the sensing and responding components is crucial to our understanding of the relation between electronic integration and agility (Overby et al., 2006). Hence, this thesis assesses the impact of electronic integration on both the sensing and responding capabilities.

Overall, internal and external electronic integration are expected to enable the process coupling and knowledge leveraging capabilities, which, in turn, facilitate sensing and responding capabilities. Building on the coordination theory and literature related to these two key elements, this thesis clarifies the relation between the two types of electronic integration and sensing and responding capabilities by specifying the mediating variables that play an important role in this relation.

1.2. Contributions

This thesis contributes to the extant literature by expanding our understanding of the integration-agility relation. Since in the current hypercompetitive environment agility and integration have become essential objectives, our work extends Barki and Pinsonneault's (2005) work by exploring the link between these two important goals. Using more specific constructs such as internal and external electronic integration, this thesis enables a fine-grained understanding of the broader relation between IT and agility. Thus, this thesis extends Sambamurthy et al.'s (2003) work that highlighted the relationship between broad IT competence and firm agility constructs. We assess how two types of electronic integration (internal and external) affect the individual sensing and responding components of agility by opening up the black-box of mediating variables and exploring the role that knowledge exploitation, knowledge exploration, and process coupling play in the integration-agility relation. This is important in order to have a clearer understanding of the impact of integration on agility. Although the current integration-agility literature has suggested a positive link between the two constructs, this research is primarily based upon low explanatory power and case study data. By investigating the integration-agility relation through the mediating variables, we will gain a deeper understanding of how this effect unfolds and what are the capabilities involved in enabling this positive effect of internal and external integration on agility.

Quite a bit of work has been done on the agility concept, but not much has been done to understand its components and how they are affected by different organizational conditions (Overby, 2006). We believe that there is also benefit in focusing on the individual sensing and responding components of agility. By distinguishing two different capabilities of agility (sensing and responding) and examining the effect of integration on these individual capabilities, we suggest a deeper understanding of how firms can develop these individual capabilities. This distinction between the sensing and responding capabilities of agility is important because firms need both capabilities to become agile (Nazir and Pinsonneault, 2012; Overby, 2006; Sambamurthy et al., 2003). Thus, this is an important contribution of this thesis. It must be noted that while this thesis investigates the relation between integration and the individual sensing and responding capabilities, the relation *between* sensing and responding and *how they constitute* the agility capability of business processes is beyond the scope of this thesis.[1] Investigating the impact on the individual capabilities is acceptable as the capabilities do not necessarily covary (Overby et al., 2006). Although we believe that they are two capabilities that together form the agility construct, it is possible that a firm might have varying degrees of sensing and responding capabilities (Dove, 2001; Bradley and Nolan, 1998; Nazir and Pinsonneault, 2012; Overby et al., 2006). By that reasoning, it is appropriate to theorize about each capability separately. The literature has suggested that rather than investigating how factors affect a complex concept like agility, it is more fruitful to investigate how factors affect the individual capabilities of sensing and responding (Overby et al., 2006). Hence, this thesis contributes to the integration-agility literature by responding to the call to investigate the impacts on the individual sensing and responding capabilities.

Overall, we intend to answer the following research questions:

Research Question 1: *What is the effect of internal and external electronic integration on the sensing and responding capabilities of business units?*

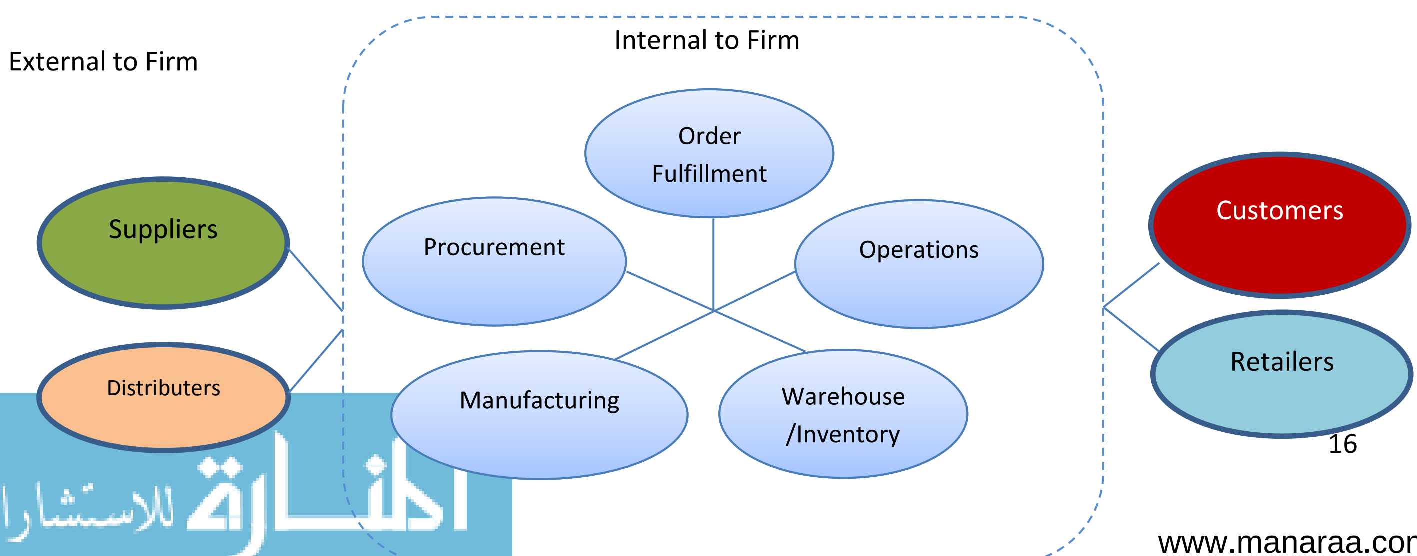
Research Question 2: *What is the role of knowledge leveraging and process coupling constructs in the relation between electronic integration and sensing and responding capabilities of business units?*

The unit of analysis for this thesis is the business unit. We use the concept of *value chain* (see Figure 1.1 below) to focus on the key functions of a business unit and to assess the impact of

[1] In this thesis we use *agility* interchangeably with *sensing and responding*. Using the term "agility" allows us to refer to both sensing and responding in a parsimonious manner.

integration on the business unit's sensing and responding capabilities. A value chain comprises the key business functions of a firm that are strategically relevant, existing, or potential sources of differentiation among firms (Bhatnagar and Teo, 2009; Porter, 1985). These key business functions in the value chain include procurement, manufacturing, operations, warehouse/inventory, and order fulfillment (Day, 1994; Rashke, 2010). These are the primary functions of the value chain and are internal to the firm. External to the value chain are the connections to entities external to the focal firm, such as suppliers and customers (Frohlich and Westbrook, 2001; Rosenzweig et al., 2003; Vickery et al., 2003), collectively referred to as external partners in this thesis. The importance of linkages among value-adding business functions has been highly stressed (Porter, 1985). Specifically, two kinds of linkages have been described in the value chain (Porter, 1985; Swink et al., 2005).

The first kind involves linkages within the value chain (internal linkages) which are internal to the value chain as well as internal to the firm. These are direct linkages among the key business functions of the value chain, such as those between order-fulfillment and manufacturing or procurement. The second kind involves linkages of the firm with external partners (external linkages) which are outside the value chain as well as outside the firm.



These are linkages of value-chain processes with upstream suppliers and downstream customers. Although customer and supplier linkages can be considered two distinct concepts that differ with regard to the direction of integration, it is the full integration with both, the upstream and the downstream side of the supply chain that gives significant benefits (Danese and Romano, 2011). Connections with upstream suppliers as well as with downstream customers are important as they make business units aware of demand (customer) changes while enabling them to respond through tight integration with the supplier side of the supply chain (Lee et al., 2008).

We investigate the impact of internal integration attained among the value chain functions of a business unit as well as the impact of external integration of our focal business unit with its business partners external to the value chain. It must be noted that while the linkages with support activities other than those within the value chain might also be important, this thesis' scope is limited to the most important processes of the firm (as shown in figure 1.1).

1.3. Format of the Thesis

The rest of the thesis is organized as follows. Chapter 2 presents a literature review of antecedents of agility. Chapter 3 presents the theoretical underpinnings. Chapter 4 presents the conceptual model and provides support for the hypotheses. Chapter 5 presents details of construct context and development. It also elaborates upon the methodology used in this thesis. It then presents the results of the data analysis. Chapter 6 concludes with a discussion of results, limitations and contributions of the thesis.

CHAPTER TWO

LITERATURE REVIEW

The literature on the relation between integration and agility is presented in table 2.1. Three observations can be made from the extant research. First, the integration-agility literature has looked at two types of integration, internal and external. Essentially, some studies investigated the effect of integration with other internal units inside the organization (Antonio et al., 2009, Booth et al., 2000; Coronado et al., 2002; Dasgupta et al., 1999; Lu and Ramamurthy, 2012; Narasimhan and Das, 1999; Putnik and Sluga, 2000) while other studies investigated the effects of integration with outside partners (Bottani, 2009; Camarinha-Matos et al., 2003; Devaraj et al., 2007; Moitra and Ganesh, 2005; Paulraj et al., 2008; Prater et al., 2001; Wang and Wei, 2007; Wieder et al., 2006). For instance, Putnik and Sluga (2007) studied firm units integrated internally through the use of modern systems such as Computer Integrated Manufacturing (CIM) systems that build on concepts such as CAD, CAM, MRP, ERP and Intelligent Manufacturing systems (IMS). Using case data they found that internal integration through enterprise systems enables agility in firm processes. Narasimhan and Das (1999) examined the effect of advanced manufacturing systems in internal units and found that integration of functional units through the use of such systems improves inter-departmental cooperation and allows coordination of activities. They reported that the degree to which IS applications of a unit work as a functional whole with IS applications of other organizational units involved in the value chain provides seamless coordination of activities and information visibility. However, this study had a low sample size and explained relatively little variance in their dependent variable. In addition, they reported mixed findings as responsiveness to changes in volume were positively affected but no effect was found on responsiveness to changes in new product development activities and modification needs. Similarly, Antonio et al. (2009) studied the effect of internal integration through enterprise systems on firm agility. The study found data and information integration to be important facilitators of close coordination among internal units, which in turn, facilitates agility at the firm level. However, this study explained a small degree of variance in their dependent variable. Coronado et al. (2002) studied integration of internal units through enterprise systems and reported that integration among internal units enhances firm capability to respond to environmental threats. Another study (Setia et al., 2008) investigated the effect of integration of internal process activities and reported that advanced planning and scheduling systems enabled organizations to quickly accommodate changes and deploy resources in order to respond to environmental change. Both these studies used case data which is not sufficient for generalizing the positive effect finding. Lu and Ramamurthy (2012) investigated how IT capability affects organizational agility, where IT capability builds on organizational ability to integrate inter-functional platforms and manage and share data efficiently such that it enables support and enhancement of business objectives. The study reported s positive effect between IT capability and organizational capability. Overall, several studies from the integration-agility literature focused on the effect of integration among *internal* units on organizational agility.

The literature also lays significant importance on integration beyond the organizational boundaries. For instance, extending the notion of integration to the suppliers of a firm, research shows that integration through IT is a key enabler of communications across all functions, departments and divisions interfacing with firm supply chain (Bottany, 2009). Essentially, the coupling that is enabled between information systems of various units beyond organizational boundaries promotes sharing of information through the use of technologies such as EDI, the internet, CAD, CAE and B2B technologies that interface with suppliers. Studies using primarily case data have shown that IT systems allow sharing of critical information and reduce the time required for sharing this information, thus enabling fast response to market change and greater agility (Gunasekaran et al., 2008). Within this external integrated research stream, some studies have also evaluated the impact of relatively newer technologies such as web services, e-business technologies and service-oriented architecture on agility (Moitra and Ganesh, 2005). Web services are a way to design seamless interaction among applications across firm boundaries. Through a standard interface, Web services allow business processes or information to be accessed over the Internet by devices ranging from handhelds to large servers (Moitra and Ganesh, 2005). Inter-organizational systems and e-business technologies have also been reported to enable agility through facilitating the seamless flow of business unit activities with outside partners (Camarinha-Matos et al., 2003). Among the studies that investigated the relation between external electronic integration and agility, only one study (Paulraj et al., 2008) used survey data to empirically test their hypotheses. The study reported finding marginally significant effects of integration on buyer firm responsiveness and no effects for supplier firm responsiveness. Overall, the literature investigating the effects of external electronic integration on agility has reported that the degree of integration that is afforded by IT applications enables agility by promoting visibility across organizational units, however, these findings are primarily based upon non-generalizable case study data or weak survey data..

In light of the observation that some studies focused on internal integration and some studies focused on external integration, we categorize the integration-agility literature into two groups, internal and external, depending on the type of integration investigated. Most studies have maintained an exclusive focus on either internal or external electronic integration. Organizations need both internal and external integration to achieve concerted, streamlined operations that enable performance gains (Chen et al., 2009). This is so because internal integration and external integration play different roles in enabling agility (Flynn et al., 2010). Internal integration tightly coordinates processes and functional units *within* the firm by streamlining process activities; external integration tightly coordinates linkages with *external* partners (customers and suppliers) by streamlining process activities external to the value chain (Flynn et al., 2010; Huo, 2012). The integration-agility literature, however, has lagged in investigating the effect of the two types of integration. Hence, there is a need to develop and test models that incorporate both types of integration. Given the importance of both internal and external integration, this thesis incorporates internal as well as external integration into one study.

Second, although several studies show that the relationship between the two types of integration and agility is positive, as also discussed above, some research found integration (both internal and external) to have no effect on agility (Booth et al., 2000; Mondragon et al., 2004; Vemuri and Palvia, 2006; Wybrow and MacDonald, 1996). For instance, research found that firms that attained internal and external integration through the use of ERP systems did not achieve any agility benefits related to integration (Mondragon et al., 2004; Vemuri and Palvia, 2006). It argued that integration achieved through enterprise systems is not sufficient to gain agility (Wieder et al., 2006). Research suggested that firms often attain internal integration of their systems but fail to gain any agility benefits due to the fact that they are not able to leverage some intervening process capabilities that may help facilitate agility capabilities (Vemuri and Palvia, 2006). Similarly, enterprise systems that provide external integration of data and processes were found to add no performance benefits even for firms that had greater organizational experience working with ERP systems (Wieder et al., 2006). Some studies suggest that external integration through information systems does not lead to agility benefits because it is the actual processes, not the integration through IS, that make overall responsiveness a possibility (Mondragon et al., 2004). To summarize, several studies found no effect of the two types of integration on agility and suggested that the two types of integration are not sufficient to gain any agility benefits. This can be explained by research based on case studies, which suggests that the integration-agility relation is, in fact, mediated by important process and knowledge mechanisms (Gunasekaran et al., 2008; Moitra and Ganesh, 2005; Mondragon et al., 2004; Putnik and Sluga, 2007). For instance, case study data on the effect of supply chain systems on agility argued that the impacts of integration should be investigated through the careful assessment of mediating effects, such as informational and knowledge linkages, that are created through integration (Gunasekaran et al., 2008). Moreover, it was argued that the coordination mechanisms between functional activities such as procurement, logistics, manufacturing operations, and sales also play an important mediating role in the integration-agility relation (Moitra and Ganesh, 2005; Putnik and Sluga, 2007; Setia et al., 2008). Hence, this thesis uses the coordination theory to understand the integration-agility relation by taking into account the process and knowledge mediating variables of the integration-agility relation.

It must be noted that the positive and no effect findings between integration and agility indicate that we do not clearly understand the integration-agility relation, especially when a majority of positive effect findings are based upon case study data or weak empirical data. Our goal in this thesis is not to resolve these conflicting positive and no effect findings. Instead we focus upon understanding better only the positive effect and investigating how this positive effect unfolds through the above mentioned process and knowledge constructs.

Third, all studies assessed the impact of integration (both internal and external) on the responding capability of agility only. Essentially, the extant research has treated responding capability as a proxy for agility. For instance, research related to the impacts of integration enabled by enterprise systems on agility in firms assessed agility as the responsiveness to changes in customer design preferences, variety in product ranges, demand response, or customer responsiveness (Antonio et al., 2009). Average process change over time, delivery time, ability to develop new products, and responsiveness in product innovation were used as measures of agility for firms that achieved integration through inter-organizational or supply-chain systems (Swafford et al., 2008; Wang and Wei, 2007). Similarly, responsiveness to changing market needs, delivery reliability, customer service, new product introductions, and reduced cycle time and lead time were also used to assess the agility of firms (Gunasekaran et al., 2008; Swafford et al., 2008). Clearly, these are related primarily to the responding capability and do not measure the sensing capability of agility. Moreover, studies related to integration enabled through web-services and e-business technologies assessed agility as the responsiveness of processes to changes in schedules, delivery speed and cost, and unexpected changes in the supplier and customer bases (Devaraj et al., 2007; Moitra and Ganesh, 2005; Wang and Wei, 2007).

One reason for this exclusive focus on responding capability by the extant literature is perhaps that responding capability might be considered the actual realization of agility. This is evident from the assertion that agility is the capability of a company to create wealth for stakeholders by *reacting* quickly and cost effectively to changing market requirements (Gunasekaran et al., 2008). Another reason might be that responding capability is considered a relatively more objectively measureable element of agility. Sensing capability might be considered relatively less objectively measureable. The literature, however, does not lend itself to a clear assessment of the reason for this exclusive focus on the responding capability of agility. This selective focus on the responding capability is rather confusing because, although the literature defines agility as having both components, it assesses the impacts of integration on the responding capability only (e.g. Coronado et al., 2002; Goodhue et al., 2009; Gunasekaran et al., 2008; Moitra and Ganesh, 2005; Mondragon et al., 2004; Setia et al., 2008; Tallon, 2008). For instance, research on the role of IT applications in enabling agility conceptualized agility as the opportunity to *discover* (or sense) new opportunities for competitive advantage and *adapt* (or respond) to these opportunities and changing business conditions; however, it operationalized agility as only *responding* to customer requests with increased accuracy and improved timeliness (Setia et al., 2008; Wang and Wei, 2007).

Table 2.1. Literature on Integration and Agility

Reference	IT Resource	Focus of Study	Sample and Methodology	Agility Construct	Findings	Mediating variables	Comments
Internal Integration							
Lu and Ramamurthy (2012)	Integrated enterprise systems	Investigate the effects of IT Capability on organizational agility	Survey of 128 matched pairs of business and IS executive	Responding to customer needs and responsiveness in business processes	IT Capability has a positive effect on organizational agility		
Antonio et al. (2009)	Enterprise systems	Investigate the effects of integration on competitive capabilities	Survey of 251 manufacturing firms	Responding capability	Integration improves the agility of the firm		Low R^2 values, $R^2 = 0.14$
Booth et al. (2000)	Enterprise systems	Assess the impacts of ERP systems on firm performance	Survey of 74 firms	Responsiveness to the environment	ERP-enabled integration did not have much effect on responsiveness of firms		

Reference	IT Resource	Focus of Study	Sample and Methodology	Agility Construct	Findings	Mediating variables	Comments
Coronado et al. (2002)	Enterprise systems	Explore the role of IS in enabling agility	Case studies of 14 manufacturing firms	Responding capability	Integration with internal units enhances firm agility	process coupling among activities	
Dasgupta et al. (1999)	Enterprise systems	Assess the value of enterprise systems on firm performance	162 manufacturing and service firms	Responding capability	Found no effect of IS-enabled integration on responsiveness to market		
Goodhue et al. (2009)	Enterprise systems	Assess business agility challenges with enterprise systems	Case studies of 15 firms	Responding capability	Enterprise systems enable opportunities to change to meet business requirements		
Narasimhan & Das (1999)	Advanced manufacturing technology	Examine the effect of AMT on strategic agility	Survey of 68 senior managers of various manufacturing industries	Responding capability	AMT enable strategic agility	None	Low R^2 values, $R^2 = 0.17$ Small sample size.

Reference	IT Resource	Focus of Study	Sample and Methodology	Agility Construct	Findings	Mediating variables	Comments
Putnik and Sluga (2007)	Enterprise systems	Assess the role of enterprise systems in agility	Case study of a manufacturing firm	Responding capability	Integration through enterprise systems enables agility in firm processes	Process coupling	
Setia et al. (2008)	Advanced planning and scheduling systems	Investigate the business value of agile enterprise systems	Case studies of 2 manufacturing firms	Responding capability (how fast changes can be accommodated; how soon resources can be redeployed; how quickly suppliers can be reconfigured)	APS were found to enhance organizational agility	Process coupling	
Tallon (2008)	Enterprise systems	Assess the impact of technical and managerial capabilities on firm agility	Survey of 241 firms	Responding capability	In turbulent environments, IS-enabled integration does not have much effect on firm agility		

Reference	IT Resource	Focus of Study	Sample and Methodology	Agility Construct	Findings	Mediating variables	Comments
Vemuri & Palvia (2006)	Enterprise systems	Assess the impact of ERP systems on firm performance	17 manufacturing firms	Responding capability	No effect of integration enabled by ERP systems was found on firm responsiveness		
Wybrow & MacDonald (1996)	Enterprise systems	Assess the impact of enterprise systems on firm agility	Case studies of two manufacturing firms	Responding capability	Found mixed results: in one firm enterprise systems were found to enable agility while in the other firm they had **no** effect on agility	The study suggests that process coupling played an important mediating role in enabling agility.	
External Integration							
Bottani (2009)	Enterprise systems	Assess the level of agility achieved based on available agility enablers	Case studies of 2 firms	Responding capability	Integration improves the agility of firms		

Reference	IT Resource	Focus of Study	Sample and Methodology	Agility Construct	Findings	Mediating variables	Comments
Camarinha-Matos et al. (2003)	Enterprise systems	Investigate the enablers of agility	Case studies of two firms	Responding capability	Integration with partners enables firm agility	process coupling among activities	
Devaraj et al. (2007)	E-business technologies	Assess the impact of e-business technologies on operational performance.	Survey of 120 manufacturing firms	Responding capability	Integration with customers was found to have no effect on agility. integration with suppliers was found to enable responding capability	None	
Gunasekaran et al. (2008)	Enterprise systems	Assess the impact of ERP systems on firm agility	Case studies of five firms	Responding capability	Integration through enterprise systems allows agility in firm processes	Knowledge exchange with external partners.	

Reference	IT Resource	Focus of Study	Sample and Methodology	Agility Construct	Findings	Mediating variables	Comments
Moitra & Ganesh (2005)	Web services	Examine the role of web services in flexible business processes and organizational agility	36 case studies	Responding capability	Web services enable organizational agility through enabling flexibility in business processes	Process coupling with organizational partners.	
Mondragon et al. (2004)	Enterprise systems	Assess the value of IS in supporting agility	Case studies of four high-tech firms	Responding capability	Enterprise systems are not sufficient to achieve agility.		
Paulraj et al. (2008)	Enterprise systems	Investigate the role of inter-organizational communication in buyer-supplier performance	Survey of 221 manufacturing executives	Responsiveness to the market.	IT-enabled integration enables responding capability in suppliers by enhancing flexibility	Process coupling	No direct effect to supplier responsiveness. Marginally significant effect on buyer responsiveness (R^2 = 0.09)
Prater et al. (2001)	Supply chain systems	Assess the role of SCM systems on supply chain agility	case study of four companies	Speed in responding to changes	SCM systems do not increase agility.	None	

Reference	IT Resource	Focus of Study	Sample and Methodology	Agility Construct	Findings	Mediating variables	Comments
Swafford et al. (2008)	SCM systems	Assess the role of integration enabled by SC systems in enabling firm agility	Survey data from 131 manufacturing firms	Responding capability	Integration enabled by SC systems does not enhance firm agility	Process coupling with external partners	
Wang & Wei (2007)	Inter-organizational systems	Examine the agility in firm supply chain through IOS	Survey of 150 manufacturing firms.	Responsiveness to the environment	IOS do not facilitate firm agility through coordination	Process coupling in activities	
Wieder et al. (2006)	Enterprise systems	Assess the impact of ERP systems on firm performance	Survey of 106 firms	Responsiveness to environment	Found no effect of integration enabled by enterprise systems on firm responsiveness		

Research on the impact of IT-enabled integration on agility defined agility as the ability to sense and respond to opportunities in the environment, however, agility was operationalized as only responding to opportunities (Tallon, 2008). We consistently found this selective focus on the responding capability of agility in both groups (internal and external integration) of the literature.

Discussion

The foregoing literature review highlights three gaps in the integration-agility literature. First, there are two types of integration – internal and external – that facilitate agility. The coupling among internal and external units enables fast sharing of important information and reduces time to respond to changes in the environment. However, the extant integration-agility literature has selectively focused on either internal or external integration. Firm units can have varying degrees of internal and external integration and this could have a differential effect on the sensing and responding components of agility. The literature has not assessed how both types of integration affect the sensing and responding elements of agility in one model. To understand the effect of integration on agility, it is important to investigate how both internal and external connections enable sensing and responding capabilities in a combined manner. Thus, there is a need to assess the impact of both internal as well as external integration in one model in order to understand their individual effects on agility.

Moreover, the integration-agility literature has focused only on the responding element of agility. The broader agility literature has clearly established that both sensing and responding capabilities are integral parts of agility (e.g. Overby et al., 2006; Sambamurthy et al., 2003). It has also been established that sensing and responding capabilities are independent and do not necessarily covary (Nazir and Pinsonneault, 2012; Overby et al., 2006). That is, it is possible that a firm unit has high sensing capability but, due to poor internal integration, its responding capability is lowered. On the other hand, it is also possible that a firm unit is able to respond swiftly but lacks the connections that allow it to sense market change. Hence, in order to fully understand the impact of integration on the entire concept of agility, it is essential to assess its effect on sensing as well as responding capability. This clearly is an avenue that needs further research to fully understand the integration-agility relation.

Finally, findings of a positive effect (Antonio et al., 2009; Narasimhan and Das, 1999) as well as no effect (Booth et al., 2000; Mondragon et al., 2004; Vemuri and Palvia, 2006; Wybrow and MacDonald, 1996) of integration on agility indicate that we lack a clear understanding of the integration-agility relation, especially when the studies supporting a positive effect are based primarily on case data or weak empirical data. Indeed, out of the thirteen studies supporting a positive effect nine are case studies, while three are using survey data with small sample sizes and weak to non-significant effects. Moreover, we also need to further investigate the mediating variables involved in the integration-agility relation. Case study research argued that knowledge exchange with external partners plays a key mediating role in the integration-agility relation (Gunasekaran et al., 2008). Research also argued that coordination among process activities plays an important mediating role in the integration-agility relation (Moitra and Ganesh, 2005; Putnik and Sluga, 2007; Setia et al., 2008). With the exception of these case studies, the overall integration-agility literature has left the mediating mechanisms in the integration-agility relation unexplored. This is perhaps one reason for the lack of a clear understanding of the integration-agility research. In order to better understand the integration-agility relation, it is important to explore these mediating variables. Research is needed to build upon existing qualitative case studies to gain more insights into the mediating mechanisms and their role in the overall integration-agility relation through larger cross-sectional studies.

We use coordination theory's ideas of advanced structuring and dynamic adjustment to open the black box of the mediating variables that inform the integration-agility relation. We believe that *process coupling* among internal and external activities of a business unit is an important advanced structuring coordination mechanism because it requires deciding up front how process activities will flow in a streamlined, synchronized fashion (Espinosa et al., 2007). Dynamic adjustment is another coordination mechanism that allows firm units to achieve coordination through feedback among process activities. Thus, units can continuously exchange knowledge about changes in their environment, which allows process activities to adapt to each other and to the environment. The exploration of new knowledge from external contacts and exploitation of existing knowledge from internal functions within the value chain allows adjustment through feedback. Keeping in mind this relation of process coupling and knowledge exploration/exploitation with advanced structuring and dynamic adjustment, respectively, we investigate the role of internal and external process coupling and knowledge exploration and knowledge exploitation as mediating variables in the integration-agility relation.

To summarize, the integration-agility literature presents several opportunities for further research. The relation between integration and agility is not well understood and needs further clarification using the knowledge and process mediating variables. Moreover, there is a need to incorporate both the sensing and responding elements of agility. Finally, there is a need to investigate the impact of both internal and external integration on the sensing and responding capabilities. We elaborate upon how we use coordination theory's advanced structuring and dynamic adjustment concepts to extend the current integration-agility literature in the following chapter.

CHAPTER 3

THEORETICAL BACKGROUND

This chapter presents the conceptual foundations of our research model. First, we elaborate how coordination theory informs the relationship between IT-enabled integration and sensing and responding capabilities. Then we explain how coordination theory allows us to specify the mediating variables that might play an important role in this relation.

3.1. E-Integration and Sensing and Responding Capabilities: A Coordination Theory Perspective

The agility literature suggests that the ability to sense and respond to opportunities and threats is enhanced by assembling requisite assets, knowledge, and relationships with speed (D'Aveni, 1994; Dove, 2001; Overby et al., 2006; Sambamurthy et al., 2003). An essential element in gaining these two capabilities, therefore, is the ability to seamlessly coordinate operations and utilize the knowledge of internal and external environments (Sambamurthy et al., 2003). As opportunities and threats emerge in firm environments at a rapid pace, organizational tasks become more complex and difficult to achieve by individual organizational functions (Espinosa et al., 2002). These opportunities and threats cannot be handled by organizational functions in isolation since, as the complexity of organizational tasks increases, the dependencies among organizational functions become more numerous and intricate in such hypercompetitive environments (Bailey et al., 2010). Hence, firm functions have to continuously coordinate their activities with other internal functions and external partners in order to execute these complex tasks that draw upon the expertise of not one but several other domains of knowledge. In simpler tasks with few actors and few changes in the environment, coordination is often handled through observing common social conventions such as talking to each other or monitoring the situation (Mintzberg, 1983). However, in contexts where multiple parties work to accomplish collaborative tasks to respond to threats and opportunities in the environment, tasks often require careful management and synchronization of knowledge and process activities (March and Simon, 1958). The seamless flow of knowledge and processes among interdependent organizational units can be achieved by careful coordination of activities (Espinosa et al., 2007; Malone and Crowston, 1990, 1994). Coordination theory (March and Simon, 1958; Malone and Crowston, 1990) can provide important theoretical support in understanding how process activities that are interdependent in nature can be seamlessly coordinated to achieve agility. Coordination theory argues that when multiple units or resources need to interact in a synchronized manner to carry out a joint task, an essential requirement is the need to manage dependencies among the units (Bailey et al., 2010). A well-coordinated system is one that reduces gaps in knowledge and process flows and provides seamless synchronization among activities (Espinosa et al., 2002). This seamless flow is created through the sharing of knowledge among units (Gosain et al., 2005; Saraf et al., 2007). Thus, units can achieve unfettered communication with each other and sense and respond to opportunities and threats emerging in their environment. Moreover, the seamless flow is created by enabling process linkages among units (Gosain et al., 2005; Saraf et al., 2007). This facilitates the units in achieving the ability to be responsive to their environment by enabling efficient coordination among activities.

In summary, coordination theory posits that coordination among organizational functions can be achieved through process and knowledge linkages that facilitate the elimination of gaps in process activities. By enabling coordination, units gain an enhanced capability to sense and respond to opportunities and threats in the environment. In addition to understanding the knowledge and process elements of coordination, it is also important to understand the devices that enable coordination. Coordination can be achieved through various devices such as written plans, schedules, manuals, or other specifications (Malone and Crowston, 1990). For instance, a flight schedule or a traffic signal can provide coordination among flights or cars, respectively (Espinosa et al., 2002). Coordination can also be achieved through computer systems such as document-sharing systems, bulletin boards, electronic mail, electronic meeting systems, and enterprise systems (DeSanctis and Jackson, 1994; Gosain et al., 2005; Malhotra et al., 2007; Saraf et al., 2007). Our focus is on the role that integration, enabled by enterprise systems, plays in facilitating *coordination mechanisms* among organizational units, which in turn enable sensing and responding capabilities. Coordination theory (Malone and Crowston, 1990; March and Simon, 1958) explains two coordination mechanisms that might help understand the relation between electronic integration and sensing and responding capabilities.

3.2. Coordination Mechanisms: The Mediating Variables of Integration-Agility Relation

Coordination theory argues that coordination can be achieved through two mechanisms, coordination by plan and coordination by feedback (March and Simon, 1958). ***Coordination by plan*** is based upon pre-established schedules and structures. In this type of coordination, streamlined linkages have been created and decided upon up front with utmost detail (March and Simon, 1958). Coordination theory suggests that units use this coordination mechanism for the most routine aspects of the task because the respective dependencies are more predictable, and hence, can be easily managed in a programmed way (Bailey et al., 2010; Espinosa et al., 2002;

March and Simon, 1958). Researchers have used different terms for this type of coordination such as "impersonal mechanisms" (Van de Ven et al., 1976), "administrative coordination" (Faraj and Sproull, 2000) in team settings, and "advanced structuring" in organizational settings (Gosain et al., 2005). Advanced structuring implies the creation of streamlined process linkages among organization functions (Gosain et al., 2005). The formalized manner in which standardized communication protocols and inputs and outputs of processes have been predefined and embedded in integrated enterprise systems are a manifestation of the "advanced structuring" that is enabled by enterprise systems. We refer to this advanced structuring mechanism of streamlining process activities as ***process coupling***.

Process coupling can be achieved either within organizational units (Antonio et al., 2009) or with units outside of firm boundaries such as with suppliers, partners or customers (Rai et al., 2006; Wang and Wei, 2007). Research suggested that companies that are able to achieve greater internal integration are better able to combine, coordinate, and connect internal process activities (Antonio et al., 2009). This improved coupling can improve agility in product development. Firms that relied on attaining close process coupling with their supply chain partners were able to achieve coordination in their processes, and hence, were more responsive to market change (Power et al., 2001). Research related to the business value of IT applications in the supply chain context suggested that firms use the process coupling achieved through IT to achieve a greater ability to coordinate process activities, reschedule jobs, and reassign resources due to changes in demand or resource constraints (Setia et al., 2008). Moreover, it was suggested that firms are able to improve their responsiveness by achieving virtual integration of operations (Wang and Wei, 2007). In essence, integration allows firms to have tight process coupling through collaborative operation execution and collaborative process planning and control (Wang et al., 2006), which improves firm responsiveness to the environment.

A study reported that firms in dynamic environments have high agility when they adopt multi-lateral inter-organizational information systems to integrate their processes with outside partners (Silveira and Cagliano, 2006). This is because the use of information systems enables closer process coupling with the supplier and customer base. The sourcing literature stresses the streamlining of process activities with partners as an important enabler of agility. For instance, research reported that firms that maintain communication channels with suppliers enjoy efficient exchanges of process-related information, which is vital to maintaining agility (Hoyt et al., 2007). This enables firm units to respond to customer demands and fluctuations in resource availability.

Advanced structuring (coordination by plan) involves several sub-processes such as identifying goals, ordering activities, assigning activities to actors, allocating resources, and synchronizing activities (Malone and Crowston, 1990). Essentially, these approaches enable coordination among processes and improve visibility. Coordination is facilitated by enabling the perception of common objects that might be relevant to the parties involved in an exchange relationship (Malone and Crowston, 1990). Technology enables parties involved in an exchange relationship to see the same physical objects simultaneously. For instance, enterprise systems might allow collaborating partners to access shared databases, giving visibility across the units. This has the ability to create a smooth flow of information that moves through standardization of communication protocols. One example of this streamlined flow of activities is the process of selecting potential contractors to perform a certain activity. A client unit starts the process by expressing its needs for certain products. The message includes information about the requirements and the description of the activities to be performed. Potential contractors receive this information and assess whether or not to submit a bid. The potential contractors send back their qualifications along with their availability to perform the required activities and price quotes. The client receives the notices from all interested contractors and decides which is the most suitable contractor. It sends a notice of acceptance to the winning contractor and informs other contractors that their bids have been rejected. This whole process represents the process coupling of activities that is afforded by integration enabled through enterprise systems.

Essentially, the above-mentioned literature suggests that internal and external process coupling, which can be achieved through various mechanisms such as virtual integration of operations or assimilation of IT in firm processes, plays an important role in enabling agility. This is because process coupling (internal and external) improves the ability to coordinate processes across organizational units and organizational boundaries, which results in smooth information, goods, and financial flow (Rai et al., 2006). Based on this literature (Antonio et al., 2009; Power et al., 2001; Setia et al., 2008; Wang and Wei, 2007; Silveira and Cagliano, 2006), we expect IT-enabled integration to lead to internal and external process coupling (Saraf et al., 2007), which in turn enables the responding capability.

The second coordination mechanism, ***coordination by feedback***, is achieved through the exchange of knowledge and is related to unanticipated changes in the environment. This coordination mechanism is used for managing exceptions and unplanned changes (March and

Simon, 1958). When organizational routines change or when tasks have few or no routine aspects, coordination by plan mechanisms are less effective because dependencies among units can no longer be managed in a programmed way (Bailey et al., 2010; Espinosa et al., 2002; March and Simon, 1958). Under such circumstances organizational units need to communicate to cope with changing situation, or to adopt new mechanisms which are more suitable to the new situation. Researchers have used different terms for this type of coordination such as "personal" or "group" mechanisms (Van de Ven et al., 1976), "mutual adjustment" (Thompson 1967, Expinosa et al. 2002), and "dynamic adjustment" (Gosain et al., 2005). Dynamic adjustment implies exchange of knowledge among organizational units to cope with impending changes. The communication of messages, information, and broadly speaking, *knowledge* that is enabled by enterprise systems is a manifestation of the "dynamic adjustment" enabled by these IT applications.

The knowledge stocks and flows that organizational units work with constitute important drivers of agility (Braunscheidel and Suresh, 2009; Gunasekaran et al., 2008; Hoyt et al., 2007; Vazquez-Bustelo et al., 2007). The literature points to the importance of fostering a learning environment to develop greater capability to manage change in external environments (Gunasekaran et al., 2008). For instance, research reported that exploring new avenues of knowledge outside the organization allows organizational units to collect information related to potential threats and opportunities in their environment and respond to them (Hoyt et al., 2007). The knowledge transferred between units can be business insights related to process and product improvements, new business opportunities (Im and Rai, 2008), competitor and regulatory environments (Saraf et al., 2007), and strategies for long-term success (Im and Rai, 2008).

Enhancing organizational knowledge is crucial for the development of agility in business units (Fink and Neumann, 2009; Overby et al., 2006; Sarker and Sarker, 2009). Knowledge is enhanced by an increased ability to access, synthesize, and exploit a wide range of sources (Overby et al., 2006). The role of IS applications in enhancing knowledge through partnering units (internal and external) is also well highlighted in research related to the impacts of IS on knowledge management (e.g. Carlile, 2002, 2004; Malhotra et al., 2007). Inter-firm IS applications play the role of boundary objects that enable knowledge transfer across three boundaries. First, boundary objects enable knowledge transfer across the syntactic boundary. This is achieved through use of common syntax and common lexicons. The common syntax enables smooth flow and processing of information across partnering units. Second, boundary objects enable knowledge translation across the semantic boundary of the partnering units. This is achieved by developing common meanings that enable shared understanding (Carlile, 2004). Knowledge sharing and its subsequent translation from one functional unit to the other are achieved by reconciling discrepancies in meaning (Dougherty, 1992; Nonaka and Takeuchi, 1995). Finally, boundary objects enable knowledge transformation across the pragmatic boundary of the partnering units. This is achieved by providing effective means for representing and negotiating the interests of different functional units (Carlile, 2002; Malhotra et al., 2007). Research has conceptualized standard enterprise business interfaces as boundary objects that enable collaborative information and knowledge exchange across supply chain partners through their integrational capabilities (Malhotra et al., 2007). Hence, it is the degree of integration afforded by IS applications that enables knowledge transfer among collaborating partners (Malhotra et al., 2007; Saraf et al., 2007).

Research suggests that IT-enabled integration allows firm units to leverage knowledge that is related to the "understanding of patterns related to external market (key markets, customers, competitors, or suppliers)" (Malhotra et al., 2007). Essentially, this is sensing-related knowledge. It further suggests that such integration also enables the transfer of response-related knowledge which is related to execution skills and capabilities (Saraf et al., 2007; Im and Rai, 2008). This knowledge constitutes not only transactional information, but also collaborative information. Transactional information is that which holds information about day-to-day transactions such as purchase orders, delivery notes, and purchase receipts. In contrast, collaborative information is *value-added* information that goes beyond normal transactional data. It consists of information about market trends, changes in customer preferences, new product introductions and future product plans as well as information related to process improvements and strategic directions (Malhotra et al., 2007; Saraf et al., 2007). Moreover, it is information that is characterized by granularity and depth.

Dynamic adjustment (coordination by feedback) involves sub-processes such as sharing knowledge and information through establishing common languages, and seeing and accessing shared databases (Malone and Crowston, 1990). Using coordination theory, Gosain et al. (2005) argued that these processes can be enabled using two approaches that characterize dynamic adjustment among interacting units: sharing information that is broad-ranging and of high quality; sharing deep coordination-related knowledge. Specifically, these approaches enable dynamic adjustment in processes by facilitating the communication of knowledge about the product/service and the market environment. One example of this is the use of communication messages (Malone and Crowston, 1990). When a design unit posts a message about changes to a design that has already been submitted, the system generates messages that inform all parties that might be affected by this change. Likewise, if a supplier posts a message that it will be unable to deliver the promised quantities to downstream customers, all customers are informed of the impending change. This allows adjustment in activities that are interdependent. Moreover, it can also allow sharing knowledge of changes that might be imminent in the environment, like information about changes in customer preferences or changes in forecast levels.

In essence, electronic integration allows firm units to create standardized communication protocols that enable shared meanings and bring knowledge from diverse sources, which facilitate the ability of the focal unit to sense changes in its environment and respond to them. These changes can be related to demand variations, customer requirements, competitor product launches, opportunities for expansion, technological changes, etc. This knowledge can be obtained primarily from two sources – existing sources inside the organization or new sources outside the organization (von Krogh et al., 2001). Based on the type of knowledge (existing or new) being accessed, we use two sets of knowledge management activities – knowledge exploitation and knowledge exploration (von Krogh et al., 2001). Knowledge exploitation is related to drawing upon the *existing* domains of knowledge such as internal functions. Knowledge exploration is related to securing and developing knowledge from *new* domains such as external partners and customers. Integrated systems such as enterprise systems and SCM systems play an important role in enhancing organizational knowledge from both existing and new sources, and therefore enhance the speed and agility of units. For instance, collaborative IT systems can be used to allow internal functions to access pertinent information that is required for solving problems in a rapid manner, which in turn improves the agility of the business unit

(Gunasekaran et al., 2008). Thus, integration among internal functions facilitates *knowledge exploitation,* which enhances agility in units (Nair and Swink, 2007). Moreover, supply chain systems that enable external integration were found to facilitate supply chain flexibility through the enabling effect of knowledge exchange with external partners (Paulraj et al., 2008; Power et al., 2001; Swafford et al., 2008). Hence, integration with external sources facilitates *knowledge exploration* through external partners and therefore enhances agility in units (Devaraj et al., 2007). We expect that internal and external integration allow the leveraging of existing knowledge domains from units internal to the value chain (knowledge exploitation) and appropriating knowledge from units external to the value chain (knowledge exploration), which in turn facilitate sensing and responding capabilities (Sambamurthy et al., 2003; Saraf et al., 2007).

To summarize, coordination theory allows us to reason that enterprise systems (specifically, the integration enabled by them) act as coordination devices that facilitate coordination mechanisms such as internal and external process coupling and knowledge exploitation and knowledge exploration. These coordination mechanisms reduce gaps in process and knowledge flows by creating seamless process and knowledge linkages among interdependent functional activities. These links facilitate the ability to sense changes in the environment and make units responsive to these changes through speedy communication of knowledge among functions and quick adjustment of processes. Overall, this enhances the agility of the focal unit. Hence, internal and external process coupling and knowledge exploitation and knowledge exploration play a mediating role in the relation between integration and agility. We elaborate further on the reasoning regarding these relations in Chapter Four, where we present our conceptual model along with formal hypotheses.

CHAPTER FOUR:

RESEARCH MODEL AND HYPOTHESES

As argued earlier, IT-enabled integration facilitates sensing and responding through coordination achieved using two mechanisms – advanced structuring and dynamic adjustment (Gosain et al., 2005; March and Simon, 1958; Malone and Crowston, 1990). In advanced structuring, firm units establish streamlined process linkages that enable the smooth unfettered flow of information (Gosain et al., 2005; Rai et al., 2006). Thus, process activities are seamlessly coordinated such that they behave in an operationally synchronized manner. This is process coupling among process activities. Since this process coupling can be external as well as internal to the value chain, we expect internal process coupling and external process coupling to be important mediating variables in the integration-agility relation. In dynamic feedback, firm units constantly communicate information about their capabilities as well as current and future changes in their respective environments. Coordination of activities is achieved by sharing knowledge about changes that allow quick sensing and adjustment in activities such that actions of the collaborating units are attuned to change in the environment (Gosain et al., 2005). We expect that gaining knowledge that exists within the organizational boundaries – knowledge exploitation – and knowledge which can be accessed from outside organizational boundaries – knowledge exploration – are important mediating variables in the relation between integration and agility. The following section presents our research model and formal hypotheses.

4.1. Research Model and Hypotheses

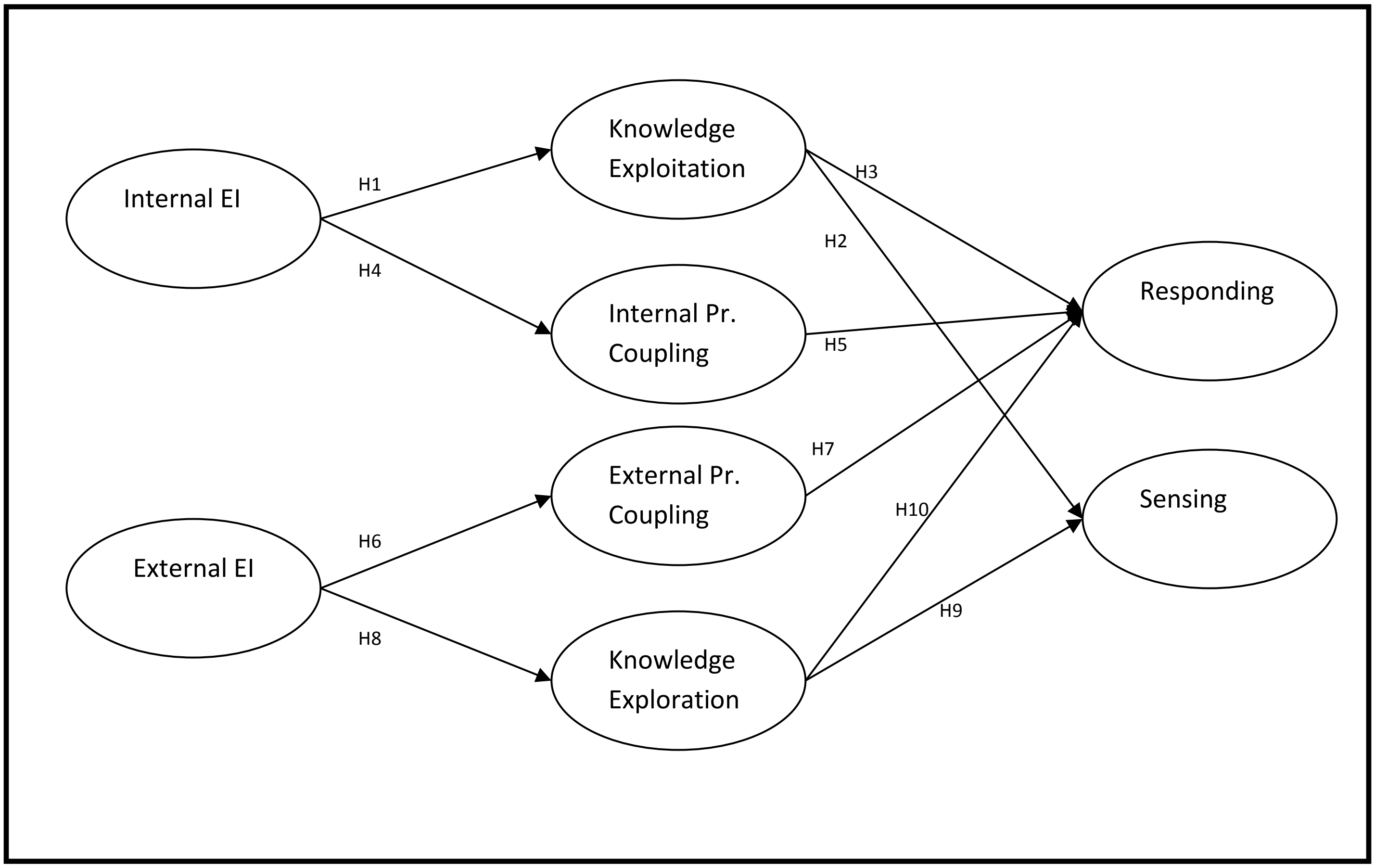


Figure 4.1: The Effect of Electronic Integration on Sensing and Responding Capabilities

4.1.1. Internal EI → Knowledge Exploitation

Electronic integration of internal value chain applications serves as an important enabler of a unit's ability to exploit current knowledge sources for the following reasons.

First, to achieve electronic integration, firm units must resolve differences in both the syntax and the semantics of data, reconcile differences in the standards for data exchange, and integrate applications (Rai and Tang, 2010). Electronic integration, therefore, standardizes communication protocols and data schemas (Barki and Pinsonneault, 2005). This standardization of communication protocols has the potential to enable development of shared meanings and emergence of a common language among functions internal to the unit (Goodhue et al., 1992). A common language (as enabled by standardized communication protocols and data schemas) forms the basis of knowledge transfer and subsequent combination from organizational functions (Grant, 1996). By enabling a common language, electronic integration allows for efficiency in knowledge transfer between individual functions, which hold specialized knowledge about their processes and market environment. Essentially, standardized communication protocols enhance the unit-level capability of acquiring, transforming, mixing, and matching knowledge across various value-chain activities of the firm (Saraf et al., 2007).

Moreover, as electronic integration standardizes organizational data and processes across different value chain activities, complex and tacit knowledge related to markets and procedures is converted into simple and explicit knowledge. Conversion of knowledge at the functional level into explicit knowledge eases knowledge transfer among the functions (Kessler et al., 2000; Nonaka, 1994). This conversion of complex knowledge into explicit knowledge means that functional units can easily allow other units to use information to make changes at their ends.

Finally, integration of internal activities streamlines primary operations and improves task efficiencies and coordination among the functional units (Gattiker and Goodhue, 2005). This improved coordination brings together the perspectives of different functional units. The scope and depth of existing knowledge expands by bringing additional expertise from other internal units. For instance, an ethnographic study (Carlile, 2002) showed how a CAD system, serving as a repository for supplying a common reference point of data, measures and labels, allowed for development of shared definitions of the issue that helped in cross-boundary problem solving. Using the standardized forms and reporting formats of the system, engineers in different operational areas were able to understand the other party's perspective and exploit knowledge from existing knowledge domains, which was not possible before the system. The CAD system enabled development of a common vocabulary among different functional units and promoted cross functional interaction and knowledge exploitation. Following this reasoning, we expect that internal electronic integration of internal value chain activities such as manufacturing, operations, inventory management, order-fulfillment and procurement allows a business unit to exploit existing knowledge in the value chain. Due to the development of shared understandings, the business unit will able to increase knowledge flows within the value chain (Tasi, 2001). This facilitates knowledge exploitation among the value chain activities of the business unit (Galunic and Rodan, 1998). Hence, we propose:

Hypothesis 1: Internal electronic integration is positively related to knowledge exploitation.

4.1.2. Knowledge Exploitation → Sensing Capability

Opportunities can exist in varying forms ranging from new ideas to improvements in products and services to creation of new products that capture customer attention and create value for them. Knowledge exploitation from value chain activities within a business unit will play a crucial role in allowing a unit to sense new opportunities related to changes and developments in the external environment (such as customer environment, market environment, and competitor environment). Sensing is related to understanding changes associated with demand, new product development, product mix, product pricing, market expansion, process capabilities, and supplier selection. Sensing opportunities in the environment requires that problems and opportunities be viewed from different perspectives. Research shows that the combination of knowledge from different sources is the key to the ability to sense a new opportunity (Aranda and Molina-Fernandez, 2002) for the following reasons.

Leveraging knowledge from various internal functions creates a knowledge overlap which increases a unit's ability to sense impending change (Tyre and Hauptman, 1992). It is often the case that knowledge about current processes and their performance is embedded in manufacturing areas and that knowledge about daily decisions involving technology use are embedded in the operations area. Hence, relevant functions might have just one piece of the puzzle, which limits the unit's ability to see the entire picture (Amit and Zott, 2001). Knowledge exploitation from relevant functions within the value chain opens up communication channels and allows for sharing of knowledge, which facilitates sensing various aspects related to imminent changes in the environment (Tyre and Hauptman, 1992). In particular, this increased communication of knowledge reduces information asymmetry among organizational units and allows for greater sensing of issues and changes in the customer, product, and market environment (Gulati et al., 2000; Amit and Zott, 2001).

Research shows that exploiting knowledge from subunits enhances sensing capability and facilitates opportunity scanning in the environment by increasing the information processing capacity of the business unit (Galbraith, 1973; Gupta and Govindarajan, 2000; Hansen, 2002). This is because access to knowledge from several functions enables the business unit to make sense of a larger number of environmental variables, which would not have been possible with limited knowledge (Gupta and Govindarajan, 2000; Szulanski, 1996; Hansen, 1999, 2002). It also expands the range of the environment that the business unit searches.

Inter-functional knowledge links are important as they enable a learning process in which value chain units discover new opportunities through sharing knowledge with one another (Tsai, 2001). Research on diversification among organizational functions stresses the benefits of knowledge sharing among organizational functions and argues that having diverse functions sharing knowledge with each other facilitates synergy in knowledge processing. This enables the business unit to make sense of impending environmental changes and allows it to better scan its product and market environment (Gupta and Govindarajan, 1998). Research on the knowledge-based view of the firm also supports this argument (Kogut and Zander, 1992; Tsai, 2000). It stresses that knowledge sharing among organizational functions facilitates the creation and sensing of new opportunities as horizontal transfer of knowledge broadens organizational learning and sensing capabilities (Tsai, 2001). Literature on process innovations argues that when a change is impending in the environment, functional units can leverage each other's knowledge to sense and understand the effects (opportunities or threats) posed by the imminent change (Tyre and Hauptman, 1992). Inter-functional knowledge exploitation and joint knowledge-based search have been shown to be critical inputs in new product development and other technical research projects where sensing imminent change is achieved by leveraging knowledge from different functions of the business unit (Imai, Nonaka and Taekuchi, 1985).

Essentially, bringing different perspectives from multiple knowledge sources to reflect upon an issue challenges the dominant mindset and improves the chances of appropriately sensing opportunities (Brown and Duguid, 1991; Leonard and Sensiper, 1998). The diversity of knowledge that functionally dissimilar units bring to bear on an issue improves the creativity of the interacting units and improves the chances that units will be able to sense opportunities that might not be too obvious or that might even be able to turn impending threats into potential opportunities (Tsai and Ghoshal, 1998; Williams and O'Reilly, 1998).

We expect the knowledge that the business unit exploits from its value chain activities would enhance its capacity to sense market opportunities in the environment. For instance, a clothing manufacturer's business unit might leverage the marketing division's knowledge so that it can analyze sales data to understand regional preferences and combine this knowledge with the procurement division's knowledge on suppliers in order to get better pricing on the products that are high in demand. This allows sensing an opportunity to offer discounts on products that are high in demand to capture a larger share of the market. In essence, sharing of this kind of knowledge might enhance the ability to better sense opportunities. Without such heterogeneous insights a unit might simply decide in favor of the obvious solution, which might not necessarily be the most appropriate one. Hence, we propose:

Hypothesis 2: Knowledge exploitation is positively related to sensing capability.

4.1.3. Knowledge Exploitation →Responding Capability

Firm units that achieve a high level of knowledge exploitation from value chain activities attain greater responsiveness to threats and opportunities in their environment for the following reasons. First, the knowledge gained from internal value chain functions essentially enables an inside-out capability (Day, 1994; Wade and Hulland, 2004). That is, knowledge exploitation allows firm units to gain knowledge from various functions such that the expertise of various functions can be used to respond to market opportunities and competitive challenges. Spender (1992) recognizes that firms engage in two knowledge processes. One is knowledge creation, which allows the individual functions to specialize and extend their domain of knowledge. A more critical and value-adding process is that of bringing together the specialized knowledge of functions in order to respond to market requirements. This relates to the capability of responding and creating value by effecting the transformation of inputs to outputs through the efficient exploitation of knowledge of various functions (Grant, 1996). Demsetz (1991) argues that this process is crucial to enhancing responsiveness to the environment as it creates the ability to efficiently leverage the knowledge that resides within the value chain functions.

Moreover, knowledge exploitation from various internal functions also enables responding capability by enhancing the combinative capabilities of a business unit. While several innovations are the result of the application of new knowledge, many others are the result of reconfiguring existing knowledge to create architectural innovations (Grant, 1996; Henderson and Clark, 1990). Architectural innovations are the result of new combinations of existing knowledge. Knowledge exploitation allows firms to generate new combinations of existing knowledge and to exploit the unexplored potential of existing technology (Kogut and Zander, 1992). This enhances the responding capability of the business unit. The internal functions act as a network of knowledge domains that come together to respond to a problem. The expanded knowledge base has a greater ability to propose radical and complex responses to the needs of the environment (Grant, 1996). This expanded knowledge allows greater responsiveness to market changes.

Finally, higher knowledge exploitation enables routines for the continuous leveraging of current knowledge repositories. These routines are highly refined and they allow for efficiently addressing problems and opportunities and matching them with relevant knowledge (Benner and Tushman, 2003). These refined routines serve the purpose of collective memory of the functional units and provide the functionality of readily accessible memory. By bringing together knowledge from internal functions and explicitly embedding it in organizational routines, the firm enables a collective, accessible memory (Day, 1994). Knowledge repositories that are accessible through knowledge exploitation along with relevant embedded routines serve the purpose of quickly matching impending problems with appropriate responses. This accessible collective memory (data, analysis, relationships among variables) through knowledge exploitation increases the ability of the firm to respond to opportunities and threats. For instance, Unilever's Microbiological Design Approval system enables product developers to rapidly gain the knowledge of product specialists by allowing the developers to enter a product and process design and obtain an immediate assessment of the microbiological safety of the proposed product (von Krogh et al., 2001). Previously, product developers did not have direct access to the specialists and were required to actually develop the proposed product and send a sample to the central laboratory for assessment. This was often a long, slow process that significantly delayed responsiveness to market changes.

Another example is that of IGT. Until 2002, the International Game Technology (IGT) company depended on several non-integrated information systems to manage sales, customer orders, manufacturing, and accounting (Rainer and Turban 2009). The company was able to attain knowledge sharing among its three major business functions: order-fulfillment, manufacturing, and product development. As visibility and knowledge sharing increased, value chain activities were better able to respond to each other's needs and to market opportunities. The company achieved great benefits in response times as inventory turns were up and rush orders were filled in 4 weeks instead of 7 to 8 weeks with the old systems. The knowledge sharing among functions enabled company executives to quickly respond to market opportunities through appropriate channeling of company resources (Rainer and Turban, 2009).

We expect that exploitation of existing knowledge by the business unit would enhance its capability to respond to market changes. Primarily, units that gain knowledge from internal value chain activities are better able to respond to opportunities and threats. Hence, we propose:

Hypothesis 3: Knowledge exploitation is positively related to responding capability.

4.1.4. Internal Integration and Internal Process Coupling

Process coupling is defined as the intermeshing of process activities of a value chain such that they are operationally coordinated (Saraf et al., 2007). It is characterized by joint actions among units, and effective and efficient coordination of activities (Robicheaux and Coleman, 1994). Process activities that may be streamlined internally include a firm's key value chain activities such as order-fulfillment, manufacturing, supply chain, inventory management, and quality control (Subramani and Venkatraman, 2003). Internal integration enables internal process coupling for the following reasons.

First, internal electronic integration allows unfettered data access across internal functions (Truman, 2000). A high level of electronic integration entails data that is immediately accessible by other units. This seamless flow of data is characterized by not only syntactic integration of databases but also semantic integration among functions (Saraf et al., 2007; Yang and Papazoglou, 2000). It has the effect of promoting high level process coupling among participating internal functions. For instance, 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 et al., 2007). Thus, a customer order entered at one functional area can immediately start processing in all other related areas. It can trigger changes in production plans and inventory stocks as well as purchase orders for suppliers (Bharadwaj et al., 2007).

Second, electronic integration, enabled by technologies such as ERP systems, increases coordination among internal value chain activities, which enables process coupling among process activities (Bharadwaj et al., 2007). When firms attain electronic integration among internal functions, they develop standardized routines and operating procedures that allow them to coordinate processes internally (Saraf et al., 2007), thus making them responsive to opportunities. Internal integration allows a subunit to coordinate flow of inventory and orders with other subunits (Gattiker and Goodhue, 2005). Supply chain integration literature suggests that internal integration promotes connectivity in processes (Chen et al., 2009). Connectivity enables transactional efficiency such that activities in a transaction flow seamlessly through functional areas. Changes in one functional area are noticed across all connected subunits and allow incorporating corrective measures so that processes such as manufacturing, materials handling, procurement and the like remain well coordinated and uninterrupted. Enterprise systems that span internal boundaries are an example of this coordination that leads to higher process coupling in the firm.

A crucial element of integration is the simplification of processes. Integration not only connects relevant business process activities, it also requires that efforts be made to identify and eliminate excessive elements within the processes (Chen et al., 2009; Frohlich and Westbrook, 2001). In other words, the processes need to be re-engineered to improve efficiency and effectiveness. Simplification includes designing effective and efficient routines by establishing streamlined operational procedures in process activities (Bowersox et al., 1999). This has the effect of creating tightly coupled process activities, also referred to as inter-functional unification and process standardization (Bowersox et al., 2003).

The internal subunits of a firm are governed by similar goals and culture. It is often the case that internal units have similar objectives, which drive activities and decisions that promote these goals. Enterprise systems that enable integration of internal units further strengthen these shared goals by promoting visibility among various internal units (Bharadwaj et al., 2007). By enabling tight inter-unit coupling, enterprise systems improve transparency within organizational units, further strengthening coordination and alignment in process activities (Goodhue et al., 1992).

In summary, internal electronic integration provides opportunities for business units to streamline their internal processes by tight syntactic and semantic integration of process activities of the value chain. It allows development of specialized routines for interaction among internal functions through enabling standardized routines and operating procedures. We expect that the internal integration of internal process activities such as manufacturing, operations, and inventory of a business unit will enhance business unit process coupling by streamlining process activities. Hence, we propose:

Hypothesis 4: Internal electronic integration is positively related to internal process coupling.

4.1.5. Internal Process Coupling and Responding Capability

Higher process coupling is likely to play a crucial role in enabling responding capability of business units. Process coupling promotes streamlined activities that help in quickly addressing opportunities, thus making the firm unit more agile in responding to changes by creating stable patterns of communication and interaction. Therefore, higher process coupling creates inherent coordination and efficiency in the processes, which allows efficient and timely responses to opportunities. Research in the IS area has shown how process coupling plays a crucial role in making processes responsive to change (Gosain et al., 2005; Saraf et al., 2007). The primary rationale is that process coupling, by its inherent nature, allows business units to coordinate their internal process activities (Christopher, 2000; Orton and Weick, 1990). For instance, the order-fulfillment, manufacturing, and inventory management units can attain high process coupling by streamlining their activities through an ERP system. As soon as the order-fulfillment unit receives an order from a customer, the inventory unit can block off inventory of the required parts (Bharadwaj et al., 2007). Moreover, the inventory management unit can update its inventory levels and place orders to suppliers for inventory replenishments. This reduces inefficiencies, excessive inventory investments, missed production schedules, poor customer service, etc. (Christopher, 2000). Thus, process coupling among functions enables the business unit to access an increased competence base to integrate resources and to combine the varied competencies of discrete functions, which facilitate the focal unit in attaining an increased responding capability (Dougherty, 1992).

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 business grew, Harris Tea struggled with maintaining visibility and coordination among internal units and 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 in a seamless fashion. Now customers can submit orders in any format, which can be translated into user-defined formats and inputted into Harris' warehouse management and ERP systems. All internal units can immediately view orders and start adjusting activities in order to meet required demand. This allowed the business units to be responsive to changes in demands and enabled all units to decide when to execute their respective activities (Ackerman, 2007). This example highlights the positive effect of internal process coupling on responding capability of a focal unit.

Specifically, process coupling breaks down functional barriers and engenders cooperation among partnering entities. This has the effect of promoting collaboration within the traditional functional silos associated with departmentalization and specialization (Flynn et al., 2010). Tightly coupled internal units enable easy access to key operational data from integrated data sources (Lee et al., 2008). This streamlines process activities of various internal departments in an organization allowing access to customer order, inventory, and planning information throughout the value chain and retrieving inventory status in real time utilizing an enterprise wide information system between manufacturing, procurement, and sales (Lee et al., 2008). This tight coupling between internal functions improves the overall responding capability of the focal unit.

Hence, we propose:

Hypothesis 5: Internal Process coupling is positively related to responding capability.

4.1.6. External Integration and External Process Coupling

Process coupling can also be achieved with external partners. Value chain activities of a business unit such as order-fulfillment and procurement span activities that often interact with external partners (Raschke, 2010). The external process coupling construct captures this external element and relates to the full alignment of processes with partners, suppliers or customers. Electronic integration – enabled through technologies such as supply-chain management (SCM) systems, supplier relation management (SRM) systems, and customer relation management (CRM) systems – plays a central role in increasing process coupling with external partners (Saeed et al., 2005; Saraf et al., 2007).

An integrated infrastructure enabled by electronic integration allows for tight coordination of processes due to the establishment of specialized communication routines (Malone et al. 1999). Partners in an exchange relationship tailor their processes to each other and can use specialized routines to respond to each other's requirements. In order to tightly intermesh processes through electronic integration, partners in an exchange customize their processes and databases to enable syntactic and semantic integration such that the information passed along is understandable throughout the entire process chain.

After electronic integration, the chain of formerly discrete activities underlying a firm's business processes becomes a system of value-adding processes (Shah et al., 2002). Full integration of unit activities with those of its external partners enables specialized routines which ensure that both resources and actions are coordinated (Bharadwaj et al., 2007). It is this integration with external partners of the supply chain that will have synergistic effects and will result in full external process coupling (Flynn et al., 2010). Electronic integration with external partners enables partners to receive timely information regarding variations in demand, production, inventory levels, and delivery capability of suppliers, and allows manufacturers to coordinate their operations more rapidly (Bharadwaj et al., 2007; Rai et al., 2006), which thus enables greater alignment in processes such as manufacturing and supply chain management (Wang et al., 2006).

Zaheer and Venkatraman (1994) propose that electronic integration has the characteristics of vertical integration, where partners in an exchange relationship make investments that enable close process coordination and interdependence between participants. When partners in a relationship invest in mutual assets (such as SCM), they tend to be more inclined toward making the current partnership work and thus become more forbearing to each other's requirements. They may find it in their own best interest to protect these investments by becoming more flexible toward process activities rather than causing the partnership to fail by being unwilling to adjust (Young-Ybarra and Wiersema, 1999). This reduces the chance of opportunism in partner behavior. IT-enabled external integration enables hybrid governance structure and improves coordination capabilities (Clemons et al., 1993; Saeed et al., 2005; Wang et al., 2006). Such coordination promotes greater alignment of process activities and results in increased process coupling between trading partners (Paulraj et al., 2008). Following this reasoning, we propose that when the business unit is electronically integrated with external partners, it increases the external process coupling of the business unit with external partners. For instance, Mukhopadhyay and Kekre's (2002) study on the electronic integration of Precision Metal Inc.

(PMI) with its customers and suppliers shows that after external integration, the customer department was able to directly release electronic orders to PMI's order-fulfillment unit. Due to the establishment of process coupling, there was no need for customers to further verify their submitted orders. For PMI, there was no need to print out the order and re-enter the order information because it directly fed into the order-fulfillment units' applications, which in turn fed seamlessly into the suppliers' applications. Such process coupling was enabled by the external electronic integration between PMI and its external partners.

It might be argued that the relation between the above-mentioned integration and process coupling constructs may be contaminated by the possibility of an inherent high correlation among them. This might suggest that electronic integration and process coupling are not independent and perhaps tap into the same construct. In other words, this means that knowledge about one variable provides some knowledge about another variable because when one variable has high values, the other variable will tend to have higher values also. Thus, the variables are very highly correlated, which might suggest that they are two similar measures of the same construct (Tabachnik and Fidell, 2007). However, this is not true for integration and process coupling because they are two distinct constructs. Electronic integration is related to the degree to which applications of a unit work as a functional whole in conjunction with applications of other units. This refers primarily to the technical aspects of integration (i.e. data and application integration). In contrast, process coupling is more related to managerial actions. It is the extent to which units seamlessly connect their process activities (through increasing coordination and visibility in process activities). A primary aspect of process coupling is the extent to which units have established business procedures and routines that are streamlined internally and externally

(Saraf et al., 2007). It essentially represents the relational characteristic of organizational units (Rai and Tang, 2010; Saraf et al., 2007; Subramani, 2004). It is possible that units have electronic integration with each other but low process coupling of activities. For instance, EDI-based integration allows data and application integration but does not guarantee any process coupling (Truman, 2000). In contrast, it is also possible that firm units establish procedures that enable them to seamlessly coordinate process activities without the use of electronic integration. This is evident from research which argues that firms achieve coordination in their processes not primarily through electronic integration but through appropriate organizational practices such as employee trainings, workforce change, flexibility in processes, and harnessing the skills of employees (Mondragon et al., 2004). Hence, electronic integration and process coupling are two distinctly separate constructs. The relationship between these two constructs is established solely by the theoretical arguments that manifest causation (as presented in Hypotheses 4 and 6). This independence between electronic integration and process coupling has also been corroborated by previous studies (e.g. Rai and Tang, 2010; Saraf et al., 2007), which did not find any unusually high correlations between the two constructs.

Hypothesis 6: External electronic integration is positively related to external process coupling.

4.1.7. External Process Coupling and Responding Capability

By enabling process coupling in operations, a greater ability to be responsive to opportunities is gained relative to the sum of individual responsiveness of units (Dyer and Singh, 1998). We argue that process coupling with external partners enables responding capability in units due to the following reasons.

First, process coupling reduces information distortion among interacting units (Rai and Tang, 2010). Frequent, bidirectional information flows between interacting units enhances better coordination of activities, which is essential for improved responsiveness to change (Saeed et al., 2005). Process coupling provides visibility into processes that are distributed across the interacting units (Wang et al., 2006). Interacting units can easily track each other's variations in production, quality, inventory, and delivery capabilities. This allows them to achieve greater responsiveness to each other and to the environment (Wang and Wei, 2007).

Moreover, coupling through planned structuring of process links allows the maintenance of close coordination among interacting units while maintaining the requisite diversity and independence of organizational units (Gosain et al., 2005). The streamlined interfaces allow the individual units to maintain their independence and preserve the ability to react and respond to changes in the environment (Gosain et al., 2005; Orton and Weick, 1990). The diversity of partners in the exchange relationship allows them to take responsibility for sub-processes (activities) that form a complex, higher-level process. Thus, each partner executes its own chunk of the complex process independently while maintaining coordination with other partners (Gosain et al., 2005). This coordination of diverse entities allows the combination of a wider range of capabilities that are complementary and manifest greater responsiveness to each other as well as to the environment (Christopher, 2000).

In addition, close coordination facilitates streamlining of plans and actions (Rai and Tang, 2010). Due to close coordination, partners are able to rapidly and adequately react to the demands of the other partners as well as the environment (Saraf et al., 2007). Specifically, process coupling allows the partners in an exchange relationship to become operationally coordinated (Robicheaux and Coleman, 1994) such that they are capable of quickly and easily responding with existing processes (Gosain et al., 2005). Responses can be efficiently orchestrated with relative ease without major penalties in time or cost because routines for responding have already been established (Amit and Zott, 2001). Existing process parameters can be customized quickly to accommodate process changes without affecting the entire process chain (Byrd and Turner, 2001).

Having process activities tailored to partner requirements coordinates activities by creating specialized routines that manifest greater comprehension of the business context (Benner and Tushman, 2003). This allows for rapid screening and development of innovations that best leverage downstream manufacturing and distribution capabilities (Benner and Tushman, 2003). For instance, it was found that firms that developed process coupling with key partners gained significant benefits in terms of product development successes, increased market share, and creation and improvement of processes (Subramani, 2004). Accordingly, firms that streamlined their processes with their external partners were better able to respond to the opportunities in their environment. The close alignment of their process activities improved their overall responsiveness to the environment.

Process coupling also has the effect of developing partnering relationships with external partners (Power, 2005). This can promote cooperation, openness of communication, and a problem-sharing attitude (Danese and Romano, 2011). Working in close contact, the focal unit and external partners can share information on unexpected problems and adjust activities accordingly. The focal unit could solicit feedback on quality and delivery performance from the customer, or involve the supplier in their quality improvement efforts (Frohlich and Westbrook, 2001). Thus, external process coupling engenders more efficient problem solving and the creation of inter-company problem-solving procedures that help in quickly responding to opportunities and threats (Danese and Romano, 2011; Frohlich and Westbrook, 2001).

Following these arguments, we propose:

Hypothesis 7: External process coupling is positively related to responding capability.

4.1.8. External EI → Knowledge Exploration

The relational view of the firm suggests that organizations often learn and explore new knowledge through their contacts with external partners (Dyer and Singh, 1998; Powell et al., 1996). In particular, tight electronic linkages with external partners allow the development of superior knowledge-sharing routines, which make it more likely that partners involved in the exchange will provide each other with new information about their environment that they otherwise would not provide (Malhotra et al., 2007). The process of creating electronic linkages promotes cooperative motivations and opens up channels of continuous interaction among partners. Electronic integration with external units manifests development of trust and a commitment to long-term interactions. Thus, it is more likely that, as compared to partners that have low or no integration, units that have high electronic integration with each other would share new knowledge that each has gathered through their respective environments. The focal unit, therefore, increases the chances of appropriating new knowledge by expanding the range of knowledge domains that it accesses through partners (Dyer and Singh, 1998).

External connections behave as weak ties which are particularly helpful in knowledge exploration (Kane and Alavi, 2008). It is often the case that tasks involving exploration are filled with uncertainty. External ties help in knowledge exploration by providing greater access to resources not found internally in the value chain (Hansen, 1999). Studies suggest that standardized systems (as enabled by electronic integration) can serve as boundary-spanning objects among firms that facilitate exploration for knowledge (Brown and Duguid, 1998; Carlile, 2002; Kane and Alavi, 2008; Malhotra et al., 2007). Carlile (2004) proposes three boundaries – syntactic, semantic, and pragmatic – that affect knowledge appropriation across existing partnering entities. Knowledge transfer across the syntactic boundary requires that partnering entities develop a common lexicon/language. The syntactic boundary proves problematic when actors do not use a common lexicon (a common syntax) to transfer knowledge (Carlile, 2004; Malhotra et al., 2007). As novelty arises in the boundary, the common lexicon fails to successfully transfer this new knowledge because it does not have the capacity to accommodate this novelty. Thus, in addition to the common language, the entities involved in an exchange need to span the semantic boundary. The semantic boundary requires that the entities also develop common meanings that enable translation of knowledge across the boundary. The semantic boundary becomes a problem when the common lexicon has been established but the terminology in the lexicon does not mean the same thing across the boundary (Carlile, 2004; Malhotra et al., 2007). Finally, at the highest level, the pragmatic boundary requires the resolution of differing interests of the partnering entities. Boundary objects help in resolution of differing interests “by providing concrete means of representing different functional interests and facilitating their negotiations and transformation” (Carlile 2004, p. 559). Indeed, the literature suggests that common integrated systems can play the role of boundary objects and allow firm units to efficiently span the syntactic, semantic, and pragmatic boundaries (Malhotra et al., 2007). In their study of supply chain systems, Malhotra and colleagues (2007) found that standard enterprise business interfaces can enable spanning of these boundaries and, in turn, promote flow of new knowledge across boundaries. Thus, external integration can enable exploration of knowledge from existing customers and suppliers by allowing the focal unit to provide its suppliers with initial product design knowledge and getting their feedback for improvements and adjustments, or by engaging customers in collaborative design through common systems. Such high-level exchange and collaboration, as enabled through external integration, allows exploration of new knowledge pools. We expect that external electronic integration will enable the business unit to have an increased capability to explore knowledge from external partners. Following the arguments, we propose:

Hypothesis 8: External integration is positively related to knowledge exploration from external partners.

4.1.9. Knowledge Exploration → Sensing capability

Indeed, exploration for knowledge with partners outside of the firm boundaries facilitates the ability to scan for opportunities and threats in the environment. The knowledge gained from partners enables outside-in capabilities (Wade and Hulland, 2004) and allows firm units to anticipate market requirements by managing external relationships and increasing market understanding (Day, 1994; Wade and Hulland, 2004). Knowledge from external partners is non-redundant and essentially creates the ability to gain new insights about the environment (Kane and Alavi, 2008; Singh et al., 2002). This knowledge is related to competitive activity, changes in demand, and technological activity (Cho, 2006).

Although knowledge from internal functions is useful in order to continuously improve products and processes by fine-tuning routines and procedures, it does not enhance the ability of firm units to perceive new trends and it focuses them on a convergent perspective of issues (Burt, 1992). We argue that knowledge from external partners facilitates firm units in radically changing products, transforming processes, and achieving greater sensing capability. First, the knowledge acquired from external ties, due to its non-redundant and heterogeneous nature, amplifies the variance in perspectives about an issue (Powell et al., 1996). This is essential in realizing that there are other approaches to solving a problem. Working with diverse technologies and processes, firm units learn new competencies and incorporate them into their processes, which allow them to devise ways to strategically *reorient* their activities. This allows them to perceive a broader array of opportunities and threats. In addition, it also allows them to sense the opportunity from different perspectives (Hansen, 1999).

Moreover, diverse knowledge from external partners eliminates the three myopias of learning: temporal, spatial, and failure (Levinthal and March, 1993). That is, knowledge exploration through external partners allows learning about opportunities that enable long-term rewards and sustaining competitive advantage. In addition, this knowledge encourages risk-taking behavior as more of the environmental variables become clear. Finally, knowledge exploration allows a firm unit to focus on distance search rather than merely on local search within the organization, thus enabling greater sensing opportunities (Im and Rai, 2008). In knowledge exploitation from internal functions, the firm tends to interact with and acquire knowledge from only a limited number of functions. This limits firm ability to perceive new trends since this knowledge is not as broad ranging as the knowledge gained from external partners (Capaldo, 2007; Langdon, 2006).

Finally, repeated interactions with diverse external partners force the focal unit to master diverse processes that enhance its absorptive capacity (Cohen and Levinthal, 1990; Im and Rai, 2008; Rodan and Galunic, 2004). Greater levels of interaction with heterogeneous and non-redundant knowledge from external partners force the focal firm to learn and master a variety of approaches to organizing activities, which ingrains a knack for sensing changes in market trends. Thus, sensing change and opportunities in the market environment become acquired competencies in themselves for the focal unit.

Knowledge sharing with external partners enables sensing and understanding the market environment. For instance, using inter-firm electronic linkages, Dow Chemical started extensive knowledge exploration from its customers (Chatterjee et al., 2006). Customers provided a continuous flow of knowledge regarding their needs, and market conditions and trends. In addition, Dow established knowledge exploration practices with its buyers and suppliers. Such a continuous flow of knowledge improved Dow's ability to sense market trends and improve product offerings – its customers and suppliers provide important feedback related to changes in Dow's competitive environment as well as their own needs. Similarly, IBM created its "Inside IBM" initiative, which allowed it to integrate its processes with customers over the Internet (Massey et al., 2001). As soon as a customer began a session at this portal, an applet would trigger a diagnostic device at 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, enabled IBM to quickly pinpoint customers' points of pain and recommend solutions. Additionally, using sophisticated data-mining techniques on the collected data, hardware and software problems that were likely to occur could be predicted before they happened. Moreover, customer profiles and current diagnostic information enabled IBM to position its products and services in a much more effective way by sensing the impending needs of customers. Consider the example of point of sale data that the order fulfillment area of a firm collects from its customers. Analyzing such data might help understand patterns in demand and allow for developing insights into market trends. These examples suggest that external electronic integration increases the range of environment scanning and improves the sensing capability of the focal unit (Malhotra et al., 2007).

Transfer and expansion of knowledge from external sources allows access to intellectual capital and promotes opportunity scanning, which translates into an increased capability to sense environmental threats and opportunities (Powell et al., 1999). Moreover, a firm unit that combines knowledge from its partners and customers also expands the range of the environment it surveys and thus becomes an extended enterprise (Rai et al., 2006), one that is better equipped to sense environmental changes. Following these arguments, we propose:

Hypothesis 9: Knowledge exploration is positively related to sensing capability.

4.1.10. Knowledge Exploration → Responding capability

Knowledge exploration with partners outside the firm boundaries allows the ability to better respond to opportunities and threats in the firm's environments. External partners enable units to leverage diverse domains of knowledge and hence respond to market requirements through innovative architectural innovations (Cho, 2006). We expect this enhanced responsiveness to result due to the following reasons.

Research suggests that knowledge exploration enables units to gain mastery of an uncertain situation by bringing in diverse knowledge pools (McCammon et al., 1988; Taylor, 1983). Diverse knowledge pools are helpful because they enable the unit to utilize a broader array of knowledge domains to respond effectively and efficiently to market changes. Knowledge exploration allows units to piece together bits of information that can result in new ideas for responding to the complex event faced by the units (Huang and Newell, 2003). The relationship between knowledge exploration and responding ability is based on the assumption that no one unit has all of the relevant knowledge to obtain the best solution for an impending event (Chi et al., 2007). That is, the knowledge requirements of producing a product are often much greater than one unit can effectively handle. Specialized knowledge of various external partners is a key requirement for the production of value-creating products and services, which serve as a response to market threats and opportunities (Grant and Baden-Fuller, 1995). Sharing knowledge with external units is, therefore, essential for responding capability since many products and services draw upon the knowledge of partners in a network and are not produced by self-contained units. Indeed, when firm units gain knowledge from different knowledge domains, they bring together a wider array of expertise to respond to a problem (Grant, 1996).

Moreover, knowledge from external partners improves responding capability by improving the response volume, response heterogeneity, and the complexity of the response repertoire (Chi et al., 2007). Knowledge from various external sources allows units to increase the volume of responses that they can devise to counter impending changes in the environment. Thus, the number of environmental changes that can be responded to is also larger (Chen and Hambrick, 1995), which improves the overall responding capability of the unit. Knowledge exploration also helps units to offer responses that are heterogeneous in nature. When units capitalize on knowledge from external sources, there is greater likelihood that these diverse knowledge pools allow units to respond in more than one way (Chi et al., 2007). This is important because it increases the chances of devising responses that are unpredictable to competitors and may enable units to outsmart the competition. Finally, knowledge exploration also helps units to develop responses to the environment that are complex in nature (Chi et al., 2007). Response complexity is important as it, too, has the potential to outsmart the competition. Complex responses manifest a greater understanding of market dynamics and result in a higher responding capability.

Firm units need an interaction routine to actually execute transferring and combining knowledge, which helps in responding to market needs through the combination of diverse knowledge bases (Grant, 1996). One such routine that results in increased responsiveness is the use of collaborative forecasting in supply chains (Rai et al., 2006). In collaborative forecasting, firm units might share market-level knowledge to improve responsiveness to upcoming market fluctuation. Sharing market knowledge might help them better match their capabilities with market opportunities and therefore improve their responding capability. Using collaborative forecasting, a manufacturer of a particular product might be better able to respond to downstream customers' needs by sharing forecast data with these customers. Inventory levels carried by the manufacturer can be reduced while improving customer service. This is because there is reduced risk of stock-outs and greater responsiveness to demand through the sharing of collaborative forecasting knowledge (Lee et al., 1997; Seidmann and Sundarajan, 1997). This suggests that knowledge exploration increases the ability of matching capabilities with opportunities and improves the responding capability of the firm unit, hence we propose:

Hypothesis 10: Knowledge exploration is positively related to responding capability.

CHAPTER FIVE

RESEARCH METHODOLOGY

5.1 Concepts and Measures

Chapters 2 and 3 presented literature reviews of the constructs in the model presented in Chapter 4. The primary goal of these chapters was to cover the content of the constructs of the research model. We followed standardized procedures, as presented in the works of Churchill (1979), Straub (1989) and Moore and Benbasat (1991), to develop the measurement instrument for the proposed research model. The primary sources of measurement items were previously validated scales.

Table 5.1. Definition of Constructs

Construct	Definition
Internal Electronic Integration	The extent to which IS applications of a unit work as functional whole.
External Electronic Integration	The extent to which IS applications of a unit work as functional whole in conjunction with the IS applications of external partners outside of the business unit.
Internal Process Coupling	Internal Process Coupling is defined as the extent to which process activities of a unit are intermeshed such that they are operationally coordinated.
External Process Coupling	External Process Coupling is defined as the extent to which process activities of a unit are intermeshed with external partners such that they are operationally coordinated.
Knowledge Exploitation	Knowledge exploitation is defined as the extent to which a business unit leverages existing domains of knowledge from inside the unit.

Knowledge Exploration	Knowledge exploration is defined as the extent to which a business unit appropriates new domains of knowledge, such as from sources outside of unit.
Sensing	Sensing is the ability to detect changes and developments in the environment external to the business unit (such as customer environment, market environment, competitor environment). It is related to changes in demand, new product development, product mix, market expansion and process capabilities.
Responding	Responding is the ability to change processes of the unit. It is the responsiveness to changes in demand, new product development, change in product mix, product pricing, market expansion, change in process capabilities

An effort was made to identify measurement items for the constructs from previously validated academic studies. Measures were adapted to fit the context of our research model. The primary goal in instrument development was to appropriately cover the content of the constructs while paying close attention to the wording of the items (Churchill, 1979) such that it conforms to the research context. The following sections present conceptualization and definition of constructs followed by step-by-step development of the measurement instrument. We explain the content of each construct of the research model and present the items that were initially chosen to measure the construct.

Electronic Integration:

Electronic Integration is the extent to which IS applications of a unit work as functional whole in conjunction with each other (Saraf et al., 2007). Essentially, it is composed of data integration and application integration. In accordance with past literature we conceptualize it as a reflective construct. It includes the degree to which key data elements are common among applications

(Goodhue et al., 1992; Rai et al., 2006) as well as the degree to which applications work seamlessly across units (Barua et al., 2004). Data integration is related to the degree to which common data definitions and consistency in stored data have been established across units (Rai et al., 2006). Application integration is related to the degree to which applications of various internal and external units can communicate in a seamless manner (Rai et al., 2006). Essentially, the electronic integration construct captures not just the technical compatibility of software applications at the code level but also syntactic and semantic integration at the data level (Saraf et al., 2007; Yang and Papazoglou, 2000).

Since electronic integration can be achieved by a focal unit internally within its value chain (internal functions such as manufacturing, operations, warehousing, etc.) as well as with external partners (customers and suppliers) beyond the value chain, we use two types of electronic integration – internal and external. We define internal electronic integration as the extent to which IS applications of a focal unit work as functional whole. External electronic integration is defined as the extent to which IS applications of the focal unit work as a functional whole in conjunction with the IS applications of external partners (customers and suppliers) outside of the business unit. It must be noted that our focus is the *full* external electronic integration with both the customer and supplier side of the supply chain. We refer to these two sides collectively as the external partners of the focal business process. Integration with only the customer or the supplier side does not have the potential to make a business process agile as by themselves they enable only partially connected processes (Chen et al., 2009; Danese and Romano, 2011). It is the synergistic complementary effect that enables a firm unit to see demand and supply changes simultaneously and resolve issues and leverage resources to gain opportunities (Frohlich, 2002).

The integration construct is based on the works of Saraf et al. (2007), Rai et al. (2006), and Barua et al. (2004). Integration is composed of two dimensions, data integration and application integration. The data integration dimension is related to the degree to which common data definitions have been established (Rai et al., 2006) and the degree to which data is stored consistently (Rai et al., 2006) such that it is easy to retrieve and share (Saraf et al., 2007). The application integration dimension measures the degree to which applications are seamlessly ed such that changes are automatically reflected in applications of partnering units (Saraf et al., 2007).

Saraf et al. (2007) use five measures of integration that assess the degree to which data can be easily shared among partners, the degree to which data are entered only once to be retrieved by most applications, the degree to which applications are integrated with each other and work seamlessly with each other and also the degree to which applications of vendors are inter-operable with each other. We modified Saraf et al.'s (2007) items to conform them to our context since we look at two kinds of integration, internal and external. For example, we changed Saraf et al.'s (2007) item "most of our software applications work seamlessly across our channel partners" to "most of our applications work seamlessly across internal units" to reflect our focus on internal integration. For external integration, this item was changed to "most of our applications work seamlessly with applications of external partners". One particular item from Saraf et al.'s (2007) conceptualization - "software applications on multiple machines of multiple vendors are inter-operable with each other across our channel partners" - was not relevant to our context as it measured inter-operability of applications *among* external partners. This taps into the ability of external partners to communicate with each other and does not measure the integration of these external partners with the focal unit. This particular facet of integration is not part of our conceptualization and hence this item is not retained. In addition, our construct also covers the degree to which definition of data is consistent across applications and the degree to which data are consistently stored across applications. We include Rai et al.'s (2006) and Barua et al.'s (2004) measures of data and application integration to provide these facets to our construct measures. Rai et al. (2006) also tap into the degree to which planning, transactional, supply chain and customer relation management applications communicate with the focal unit (order-fulfillment). For internal integration, we retained the planning and transactional items but discarded the supply chain and customer relation management items as they tap into external element of integration. For external integration, however, we retained all of these items. Rai et al.'s (2006) item – "automatic data capture systems are used (e.g., bar code) across the supply chain." - does not conform to our conceptualization of integration. We believe that this item is particular to the supply chain context and refers to an aspect (automatic data capture) that is not consistent with our context. Hence, we did not retain this item. Drawing upon Barua et al.'s (2004) conceptualization, our constructs of internal and external integration also include the degree to which applications can easily transmit, monitor and process data with each other as well as the degree to which changes in data are automatically reflected in downstream systems. Barua et al. (2004) also had some measures that are not consistent with our constructs or are redundant with our items. Specifically, Barua et al.'s (2004) items, "data can be easily shared among various internal systems" and "our systems allow continuous monitoring of order status at various stages in the process", are redundant with already selected items, hence we chose not to retain these two items. See appendices 1 and 2 for a complete list of original items, their adapted form, along with reasons for their adaptation. These appendices also provide psychometric properties of the integration constructs selected. The items in red were not retained as they were either redundant with other items or were not relevant to our context. Tables 5.2 and 5.3 present the final list of selected items for internal and external electronic integration respectively.

Table 5.2. Measurement Items for Internal Integration

Indicate the extent to which the following statements apply regarding the electronic integration of the manufacturing, operations, procurement, inventory, and order fulfillment IT applications within your business unit. [1=Not at all to 5=To a great extent]	
Measurement Item	**Reference**
Definition of key data elements (e.g. customer, order, part number) are common across IT applications	Rai et al. (2006)
Same data (e.g. order status) are stored consistently across IT applications	Rai et al. (2006)
Data are entered only once to be retrieved by most applications.	Saraf et al. (2007)
We can easily share our data with each other	Saraf et al. (2007)
We have successfully integrated most of our IT applications.	Saraf et al. (2007)
Most of our applications work seamlessly across units.	Saraf et al. (2007)
Order changes are automatically reflected in all IT applications.	Barua et al. (2004);
Our applications easily transmit, integrate, and process data among each other.	Barua et al. (2004);
Our transactional applications communicate seamlessly with other units (procurement, manufacturing, distribution)	Rai et al. (2006)
Our planning applications communicate seamlessly with other units (e.g. demand planning, transactional planning, manufacturing planning)	Rai et al. (2006)
All our internal units from raw material management through production, shipping, and sales are connected and integrated in real-time.	Huo (2012)
Our logistics-related operating data are searchable in real-time.	Huo (2012)

Our inventory data are searchable in real-time.	Huo (2012)

Table 5.3. Measurement Items for External Integration

Indicate the extent to which the following statements apply regarding the integration of your IT applications with the IT applications of your most important **external partners** outside the organization. [1=Not at all to 5=To a great extent]	
Measurement Item	**Reference**
Definition of key data elements (e.g. customer, order, part number) are common among our applications and the applications of our external partners.	Rai et al. (2006)
Same data (e.g. order status) stored in different databases are consistent across our applications and those of external partners.	Rai et al. (2006);
Data are entered only once to be retrieved by most applications	Saraf et al. (2007)
We can easily share our data with our external partners.	Saraf et al. (2007)
We have successfully integrated most of our applications with the applications of our external partners.	Saraf et al. (2007)
Most of our applications work seamlessly with the applications of our external partners.	Saraf et al. (2007)
Order changes are automatically reflected in applications of our external partners.	Barua et al. (2004);
Our systems can easily transmit, integrate, and process data from external partners.	Barua et al. (2004);
Our internal applications (such as our enterprise resource planning application) communicate in real time with the applications of external partners.	Rai et al. (2006)
Customer and supplier relationship applications communicate in real time with internal applications of our unit.	Rai et al. (2006)

Knowledge Exploration

In general, exploration is conceptualized as the pursuit of new ideas and the primary goal in exploration is to increase variances such that innovative solutions to problems can be found (March, 1991). It is that class of activities "whose goal is to learn about the environment and discover novel ways of creating new products and solving old problems" (Subramani, 2004). Thus, the essence of exploration is gaining new ideas, divergent thinking and variety (Bierly et al., 2009). Continuous improvement and fine-tuning of current products and practices has only a limited potential in providing long-term advantage. Gaining new ideas and variety through exploration, in contrast, allows firm units to innovate and develop new products and services that provide value, allow them to respond to the environment and remain competitive in the long term (March, 1991). An explorative orientation in firm activities promotes such actions as "search, variation, risk taking, experimentation, play, flexibility, discovery, and innovation" (March, 1991).

The key notion behind the concept of knowledge exploration is primarily accessing and understanding new knowledge and information that allows units to discover novel ways to produce value-creating products and services. Exploration is a relatively uncertain and unpredictable activity, reflecting the ability to acquire new knowledge rather than merely learning how to use current knowledge more efficiently (Liu, 2006). Essentially it creates variety in knowledge through search, discovery and innovation (Sitkin et al., 1994).

Research on exploration stresses the importance of the external acquisition of new knowledge (Raisch et al., 2009). Empirical evidence shows that exploration beyond organizational boundaries had more innovative impact than knowledge within organizations (Rosenkopf and Nerkar, 2001). Exploration has been characterized as a distance search for new capabilities, often carried out external to the organization (Benner and Tushman, 2002; Im and Rai, 2008; March, 1991; March and Simon, 1958; Weick, 1979). Exploration involves accessing and understanding information that was previously not possessed by a firm. It involves accessing new knowledge domains by transfer of knowledge from external sources (partners, alliances) (Benner and Tushman, 2002; von Krogh et al., 2001)

Supply chain systems enable firm units to acquire partnerships that bring in new competencies and facilitate collaboration to produce new insights and novel solutions. Thus, variances in process activities are greatly increased by the possibility of inclusion of new knowledge and competencies through outside partners (Benner and Tushman, 2002). Research argues that inter-organizational systems can enable firm units to span organizational boundaries and search for potential sources of new knowledge (Malhotra et al., 2007; Rai et al., 2006; Rai and Tang, 2010). Hence the range of knowledge that can be accessed is greatly increased through these inter-organizational systems. The focal firm unit can explore novel ways of solving current problems or find solutions to new problems (Subramani, 2004) by effectively communicating its needs to partners which may help in providing new knowledge (Malhotra et al., 2007). These partners may possess competencies that the focal firm unit lacks and thus enable using new knowledge to solve the problems at hand.

Following this reasoning we conceptualize knowledge exploration as gaining new knowledge from sources outside of business unit, such as downstream customers, retailers, and distributors.

It consists of appropriating and probing strategies which are related to "capturing *new knowledge* from the *external* environment, rather than developing it in-house" (von Krogh et al., 2001, p.433). For instance, using business intelligence tools, firm units can analyze market knowledge that they gain from their downstream clients to understand their market environment and customer preferences in a much profound manner. External connections can provide market, manufacturing and product knowledge that can provide unique opportunities for understanding market changes as well as developing and improving products (Im and Rai, 2008).

This construct measures the extent to which the focal unit appropriates knowledge from external partners about product or service-related changes, future plans such as promotions or capacity utilization, changes in demand trends and forecasts, changes in product volumes and features, as well as knowledge about building new products and services, or exploring new business opportunities. We conceptualize it as a reflective construct. Our construct is broader in conceptualization as compared to Malhotra et al.'s (2007) construct, hence we include Im and Rai's (2008) measures to include new products/services and new business opportunities facets. We adapted Malhotra et al.'s (2007) measures to our context. For instance, we adapted one of Malhotra et al.'s (2007) items – "extent to which you exchange details of upcoming product or service-related changes with partner company" – to "extent to which we gain knowledge of upcoming product/service related changes from external partners." We adapted all of Malhotra et al.'s (2007) measures in this manner to change the context from partner company to external partner of the focal unit. In addition, we used Im and Rai's (2008) measures to include facets such as knowledge about building new products and new services and knowledge about new business opportunities. Im and Rai (2008) had three additional items that tapped into knowledge related to strategies for long-term success, novel ideas for long-term success and new approaches for process integration of supply chain services. These are not relevant to our context and hence are not retained. For a complete list of all the original items, and their adapted form along with reasons for adaptation see appendix 3. The items in red were not retained due to irrelevance to our context. Table 5.4 presents the final list of selected items for knowledge exploration.

Table 5.4. Measurement Items for Knowledge Exploration

Indicate the extent to which your business unit engages in the following activities with your most important external partners outside the organization [1=Not at all to 5=To a great extent]	
Measurement Items	**Reference**
Extent to which we obtain new knowledge from external partners to help in building new products.	Im & Rai (2008)
Extent to which we obtain details of upcoming product related changes from external partners	Malhotra et al. (2007)
Extent to which we obtain details of changes in product features or volumes from external partners	Malhotra et al. (2007)
Extent to which we obtain knowledge about new business opportunities from external partners.	Im & Rai (2008)
Extent to which we obtain knowledge of future plans such as promotion and marketing plans, capacity utilization from external partners	Malhotra et al. (2007)
Extent to which we obtain knowledge of demand shifts and changes in customer preferences from external partners	Malhotra et al. (2007)
Extent to which we obtain knowledge related to demand trends and forecasts from external partners	Malhotra et al. (2007)
Extent to which we obtain knowledge from external partners that helps us better understand the capabilities and intentions of competitors	Malhotra et al. (2007)
Extent to which we obtain knowledge from external partners that helps us analyze and redesign processes linked to channel partners to improve the performance of the channel as a whole.	Malhotra et al. (2007)

Knowledge Exploitation

In general, exploitation of firm competencies is the continuous fine-tuning of organizational forms, routines and processes. By continuous use and refinement, organizations experience an increase in competence at an activity, which increases the likelihood of rewards for engaging in that activity. This further increases likelihood of engaging in that activity (March, 1991). The rewards that result from an exploitive orientation are, therefore, usually clear and manifest themselves in the near future. An exploitive orientation in firm activities promotes such actions as "refinement, choice, production, efficiency, selection, implementation and execution" (March, 1991). Thus, the essence of exploitation is the refinement of organization's existing products and improvement of its processes (Bierly et al., 2009; March, 1991). It is associated with convergent thinking and focus which brings about continuous refinement in ideas that improve products and processes.

Knowledge exploitation is basically the process of gaining competence by adopting, synthesizing, and applying current or existing knowledge (Liu, 2006). It involves retrieving knowledge that has already been created and internalized within an organization (Lyles and Schwenk, 1992). However, this knowledge needs to be combined and drawn upon to be effective. Exploitation is a relatively certain activity which draws upon existing firm knowledge and is characterized by refinement, efficiency and implementation of existing knowledge of a firm rather than searching for new domains of knowledge (March, 1991). Essentially it is the improvement and refinement of knowledge through following on existing technological trajectory, and building on existing capabilities (Sitkin et al., 1994).

Exploitation has been characterized as a local search that capitalizes on existing capabilities, often carried out internal to the organization (Benner and Tushman, 2002; Im and Rai, 2008; March, 1991; March and Simon, 1958; Weick, 1979). It involves accessing and combining knowledge that was previously possessed by a firm. It is often the case, however, that this knowledge is spread out in various functions of the firm. Hence, it involves accessing existing knowledge domains by transfer of knowledge among internal sources (Benner and Tushman, 2002; von Krogh et al., 2001).

Research has shown that enterprise systems can prove beneficial in accessing and transferring knowledge within organizational units (Bharadwaj et al., 2007; Carlile, 2002; Gattiker and Goodhue, 2004; Goodhue et al., 2009). By enabling seamless connections among internal functions of a business unit, an enterprise system serves as a "backbone" that connects various silos of knowledge within an organization and creates visibility that provides unfettered flow of information (Goodhue et al., 2009). This allows exploiting knowledge that exists in these subunits.

Knowledge exploitation consists of leveraging and expanding strategies which are related to transferring existing knowledge throughout the organization. These strategies ensure that the company internally transfers existing knowledge from various knowledge domains, for example in areas such as product development, manufacturing, operations, procurement, warehouse/inventory, and so forth (von Krogh et al., 2001). For instance, using a CAD system in a new product design firm, engineers were able to gain knowledge from each other and improve the product design by understanding each other's limitations better (Carlile, 2002).

Leveraging current knowledge focuses on the ability of the unit to identify potential knowledge transfer opportunities among organizational units and transfer this existing knowledge from the various knowledge domains to the entire organization (von Krogh et al., 2001). Subunits are expected to share insights, data and information with regards to improvement in processes and products by bringing in knowledge from other subunits (von Krogh et al., 2001). The literature suggests that knowledge about product and markets are two important elements of knowledge that is leveraged from internal units (Im and Rai, 2008; Malhotra et al., 2007). We base our construct on the works of Malhotra et al. (2007) and Im and Rai (2008), however, our construct varies slightly. Our conceptualization is broader than that used by Malhotra et al (2007) since they do not measure the knowledge related to refining the existing processes and products. We borrow this facet from Im and Rai's (2008) measures. Im and Rai's (2008) focus on the short term goals, low-risk and short-term performance is not relevant to our context, hence we do not draw upon those facets of their measures. We conceptualize knowledge exploitation as a reflective construct. Essentially, the construct assesses the extent to which a business unit leverages knowledge internally from its subunits about upcoming product or service-related changes, future promotions, marketing plans, capacity utilization, demand trends and forecasts, changes in demand shifts and customer preferences, product features or volumes, and other improvements in processes and products. We adapt Malhotra et al.'s (2007) items to our context. For instance, we adapted Malhotra et al.'s (2007) item – "Extent to which you exchange details of upcoming product or service-related changes with partner company" – to "extent to which we gain knowledge of upcoming product/service related changes from other internal units." This adaptation was done to change the focus from external partner to internal subunits. Similar adaptation was applied to almost all the items used by Malhotra et al. (2007). There was one item – "Extent to which you exchange information related to changes in supply chain structure, such as addition or dropping of partner companies, merger, and alliances, with partner company" – in Malhotra et al.'s (2007) measures that was specific to SC context. Hence, this item was not retained. We also used one item – "our companies exchange knowledge related to refining the existing supply chain services process" – from Im and Rai's (2008) measures of knowledge exploitation. It was somewhat specific to the SC context, hence, we adapted it to "the extent to which we leverage existing knowledge from each other to improve products" to maintain our focus on products, which is representative of our context. Im and Rai (2008) had four other items related to short-term goals, low-risk, short-term performance improvements and improvements of a few parts of the SC service processes. These were not deemed relevant to our context of knowledge exploitation among subunits and hence were not retained. For a complete list of all the original items, their adapted form along with reasons for their adaptation, see appendix 4. The items in red were not retained. Table 5.5 presents the final list of selected items for knowledge exploitation.

Table 5.5. Measurement Items for Knowledge Exploitation

Indicate the extent to which the manufacturing, operations, procurement, inventory, and order fulfillment functions engage in the following activities with each other. [1=Not at all to 5=To a great extent]	
Measurement Items	**Reference**
Extent to which we leverage existing knowledge from each other to improve products.	Im&Rai (2008)
Extent to which we obtain knowledge of upcoming product/service related changes from other internal units.	Malhotra et al. (2007)
Extent to which we obtain knowledge from each other about changes in product features or volumes.	Malhotra et al. (2007)
Extent to which we obtain process knowledge from each other to support changes in product features or volumes.	Malhotra et al. (2007)
Extent to which we obtain knowledge from each other of future plans such as promotion and marketing plans, capacity utilization.	Malhotra et al. (2007)
Extent to which we obtain details of demand trends and forecasts from each other.	Malhotra et al. (2007)
Extent to which we obtain details of demand shifts and changes in customer preferences from each other.	Malhotra et al. (2007)
Extent to which we obtain knowledge from internal units that helps us analyze and redesign processes linked to other internal units to improve the performance of the process as a whole	Malhotra et al. (2007)

Process Coupling

Process coupling is defined as the intermeshing of process activities such that they are operationally coordinated (Saraf et al., 2007). It is characterized by seamless coordination among process activities along with joint actions among functions of a business unit (Robicheaux and Coleman, 1994). A primary element of process coupling is the extent to which business procedures and activities of units are streamlined internally and externally (Saraf et al., 2007). Coupling among process activities refers to coordination information flow among partnering units that reduces uncertainty among coordinating entities. This reduces information asymmetry while improving efficiency and reducing cycle times and stock outs (Barua et al., 2004; Wang and Wei, 2007).

Since process coupling can be achieved by a focal unit internally within its value chain (internal functions such as manufacturing, operations, warehousing, etc.) as well as with external partners beyond the value chain, we use two types of process coupling, internal and external. Internal process coupling is defined as the intermeshing of process activities of a unit such that they are operationally coordinated. External process coupling is defined as the intermeshing of process activities of a unit with external partners such that they are operationally coordinated.

The process coupling construct is based on the work of Saraf et al., (2007) and Rai et al. (2006). In accordance with past literature we conceptualize it as a reflective construct. We used Saraf et al.'s (2007) five items for the coordination element of the process coupling construct. We adapted the items to our internal and external context. For instance, for internal process coupling, we adapted the item "the business procedures and routines of our business unit are highly coupled with the ones of our customers" to "the business procedures and routines of our unit are highly coordinated." For external process coupling, the original item was adapted to "the business procedures and routines of our unit are highly coordinated with procedures of external partners." In addition, Rai et al.'s (2006) concept of process integration capability was used to add more items to the process coupling construct. Specifically, Rai et al.'s (2006) items "supply chain members collaborate in arriving at demand forecasts", "our downstream partners share their actual sales data with us" and "production and delivery schedules are shared across the supply chain" were used. From Rai et al.'s (2006) work, only the third item is consistent with the internal process coupling construct, hence it was the only one retained from the three for this construct. For the external process coupling construct, all three items were retained. To see a complete list of all the original items and their adapted form, along with the reasons for adaptation and psychometric properties, see appendices 5 and 6. The items in red were not retained. Tables 5.6 and 5.7 present the final list of selected items for internal and external process coupling respectively.

Table 5.6. Measurement Items for Internal Process Coupling

Indicate the extent to which the following statements apply regarding the coordination of the manufacturing, order fulfillment, procurement, operations and inventory processes with each other. [1=Not at all to 5=To a great extent]	
Measurement Item	**Reference**
The business procedures and routines of our unit are highly coordinated with each other.	Saraf et al. (2007)
To operate efficiently, the procedures and routines rely heavily on each other.	Saraf et al. (2007)
Our way of doing business is closely linked with each other.	Saraf et al. (2007)
Most of our operations are closely connected with each other.	Saraf et al. (2007)

Our business procedures and routines are linked with the each other.	Saraf et al. (2007)
Production and delivery schedules are shared among processes.	Rai et al. (2006)

Table 5.7. Measurement Items for External Process Coupling

Indicate the extent to which the following statements apply regarding the coordination of your unit's business processes with process activities of your most important ***external partners*** outside the organization. [1=Not at all to 5=To a large extent]	
Measurement Item	**Reference**
The business procedures and routines of our unit are highly coordinated with procedures of our external partners	Saraf et al. (2007)
To operate efficiently, we rely on procedures and routines of our external partners.	Saraf et al. (2007)
Our way of doing business is closely linked with that of our external partners.	Saraf et al. (2007)
Most of our operations are closely connected with the ones of our external partners.	Saraf et al. (2007)
To facilitate operations, our business procedures and routines are linked with the ones of our external partners.	Saraf et al. (2007)
We collaborate with our external partners to arrive at demand forecasts	Rai et al. (2006)
Our downstream partners share their actual sales data with us	Rai et al. (2006)
Production and delivery schedules are shared across the supply chain with external partners.	Rai et al. (2006)

Agility

Agility has been conceptualized in several ways. The key element of agility in organizations facing uncertain and unpredictable markets is an ability to leverage operating procedures that are highly adaptive and flexible. By that logic all the activities that may be involved in enabling a firm to respond to its customers' needs through appropriate products and services may be viewed with respect to agility (Kettunen, 2009). This renders agility not unique to any of the literature streams, such as manufacturing, software development, new product development, or supply chain management. Hence, the concept can be approached from many different perspectives, such as supply chain agility, NPD agility, software development agility, IS agility, manufacturing agility, process agility and workforce agility (Bernardes and Hanna, 2009; Burgess, 1994; Kettunen, 2009).

A major part of agility literature has stressed two dimensions of the agility construct, sensing and responding. Although both these dimensions are deemed important, responding to environmental change has been the primary focus of most of the literature on agility (Borjesson et al., 2006; Fink and Neumann, 2007; Oosterhout et al., 2006; Tallon, 2008; Zain et al., 2005). For instance, the literature argues that in order to be agile, firms must construct responses that are quick and effective (Fink and Neumann, 2007). It stresses that agility is the responsiveness to changes in demand, new product development, change in product mix, supplier selection and IT adoption and diffusion (Tallon, 2008). Moreover, it conceptualizes agility as a response to the challenges posed by a business environment dominated by change and uncertainty (Zain et al., 2005).

In contrast, several studies have stressed a balanced focus on sensing and responding capabilities of agility. For instance, research stresses that firms can capture new opportunities for competitive advantage by harnessing their capabilities to sense change (Gallager and Worrell, 2008). It stresses the importance of relational and integration mechanisms in achieving agility at the local as well as organizational level (Gallager and Worrell, 2008). Case study research stressed that agility is strongly related to an organization's ability to acquire, assimilate, transform and exploit new knowledge to sense and respond to environmental opportunities (Hovorka and Larsen, 2006). The literature argues that sensing environmental change and responding readily to it are crucial elements of enterprise agility (Overby et al., 2006; Sambamurthy et al., 2003). Studies related to agility in software development and implementation (Lyytinen and Rose, 2006; Holmqvist and Pessi, 2006) have operationalized sensing through scenario development and exploration, and responding through keeping implementation projects at a small scale and quickly adopting change. The literature has also used firms' knowledge management practices as a proxy for measuring their degree of sensing capability. For instance, the capabilities to acquire knowledge and use firm's absorptive capacity have been used as proxies of the sensing capability of firms (Garison, 2009; Hovorka and Larsen, 2006). These studies assess the responding dimension using measurement items such as responding to new information or customer requests, enhanced manufacturing responsiveness and speedy operations (e.g. Garison, 2009; Hovorka and Larsen, 2006).

The foregoing discussion highlights the fact that although some literature lays more importance on the responding element, both sensing and responding capabilities are important components of the agility construct. Hence, we incorporate both the sensing and responding elements of agility. Agility is at the business unit level. It has two components, sensing capability and responding capability. Sensing is the capability to understand changes and developments in the external environment (such as customer environment, market environment, competitor environment). Our construct is broader than that of Tallon's (2008) and Raschke's (2010), as each of them focus on either the product or the process facet of the construct, while our construct focuses on both product and process facets. Hence, we combine and adapt Tallon's (2008) and Raschke's (2010) measurement items to operationalize the sensing capability. We conceptualize it as a reflective construct. As the original items are purely about responding and do not have a sensing element in them, we adapted the items to our context to reflect sensing only. For instance, the item "switch suppliers to avail of lower costs, better quality or improved delivery times" was adapted to "sense the need/opportunity to switch suppliers to avail of lower costs, better quality or improved delivery times" to reflect the sensing focus of our construct. We adapted all eight items from Tallon's (2008) measures to reflect the sensing capability. The construct assesses the degree to which the focal unit can sense changes in aggregate demand, need to customize products, new product or service launches, opportunities for expansion into regional and international markets, need to adopt new technologies, change variety of products, or switch suppliers to gain strategic advantages. We also used Rashke's (2010) measure related to the changes within the business process of the unit since that is the only measure relevant to our construct.

Responding is the capability of the business unit to respond to change. It is the responsiveness to changes in demand, new product development, change in product mix, product pricing, market expansion, change in process capabilities, and supplier selection. We adapt Tallon's (2008) and

Raschke's (2010) measurement items to operationalize the responding capability. Similar to sensing capability, the responding capability measures were derived from Tallon (2008) and Raschke (2010) to tap into the extent to which business unit can respond to changes in the external environment. In accordance with past literature we conceptualize it as a reflective construct. The original measurement items for the responding capability were retained without any changes as the items conform to our context. Refer to appendices 7 and 8 to see all the original items, along with their adapted form, reasons for adaptation and psychometric properties for the sensing and responding capabilities respectively. Tables 5.8 and 5.9 present the final list of selected items for the sensing and responding capabilities respectively.

Table 5.8. Measurement Items for Sensing Capability

To what extent can your unit easily and quickly ... [5-point Likert Scale, 1=Not at all to 5=To a great extent]	
Measurement Items	**Reference**
Detect changes in aggregate consumer demand	Tallon (2008)
Detect the need for customizing products to suit individual customers.	
Detect new product or service launches by competitors	
Detect the need to change pricing schedules.	
Detect the opportunities (expansion, partnering) in regional and international markets.	
Detect the need for changing the variety of products/ services available for sale	
Detect the need to adopt new technologies to produce better, faster and cheaper products and services.	

Detect the need/opportunity to switch suppliers to avail of lower costs, better quality or improved delivery times.	
Detect the need to change functionality of business process.	Raschke (2010)

Table 5.9. Measurement Items for Responding Capability

To what extent can your business unit easily and quickly perform the following business actions: [5-point Likert Scale, 1=Not at all to 5= To a great extent]	
Measurement Items	**Reference**
Respond to changes in aggregate consumer demand	Tallon (2008)
Customize products or services to suit individual customers	
React to new product/service launches by competitors	
Introduce new pricing schedules in response to changes in competitors' prices.	
Expand into new regional and international markets	
Change (i.e. expand or reduce) the variety of products / services available for sale.	
Adopt new technologies to produce better, faster and cheaper products and services	
Switch suppliers to avail of lower costs, better quality or improved delivery times.	
We can successfully and quickly change functionality of our business process	Raschke (2010)

5.1.2 Initial Purification of Items

The selected scales will be evaluated using a panel approach. A panel of judges consisting of IS faculty members and PhD students will be asked to participate in a q-sort procedure. Panel judges will be provided definitions of the constructs and will be asked to place items in the appropriate construct table. In addition, participants also will be asked to provide feedback on the appropriateness and understandability of the items.

5.2 Research Design

5.2.1 Unit of Analysis

The unit of analysis for the study is the business unit. This is because a major part of sensing and responding is carried out at the business unit or higher level. The sensing and responding activities performed at these higher levels help position and adjust the business unit appropriately in their business environment. The measurement scales primarily ask respondents to assess the ability at the business unit level to perform certain functions (knowledge exploration, knowledge exploitation, process coupling, etc.). In addition, the questions related to the technology component (internal and external integration) were also reworded to reflect the business unit level.

5.2.2 Key Respondents

Careful selection of the key respondents for the study is extremely important for obtaining responses that are valid, accurate, and unbiased (Huber and Power, 1985). This issue is even more important for our study as many of our constructs are boundary spanning in nature and require knowledge of various functions of the value chain such as information technology, strategic planning, and operations.

Previous studies have used high-ranking managers, IS managers, engineering executives, and other top-level executives. We believe that there are two potential candidates that can fulfill the respondent role for our study. One could be IS managers and the other could be business managers. A similar study (Saeed et al., 2005) found that although IS managers often had trouble responding to the business side of the constructs due to their limited knowledge of that domain, business managers were adept at answering both the business as well as the broad IT-related questions. Hence, we decided to select business unit managers as the key respondents for this study. This is consistent with the key informant approach, where the respondents who are most knowledgeable about the context of the study are selected (Sabherwal and Chan, 2001). On the technology side, we aimed to keep our IT-related questions at a functional level rather than a technical level so that business managers would have little trouble in responding to them.

For our data collection purposes we needed respondents who have knowledge about both the internal as well as the external aspects of the business unit. Supply chain management literature suggests that manufacturing and operations managers are often the most knowledgeable respondents because they sit at the nexus of many of organizational processes that interact with internal as well as external stakeholders (Day, 1994; Raschke, 2010; Tracey et al., 2005). Based on this reasoning, manufacturing and operations managers who have knowledge of the internal and external aspects of the business unit were selected as potential respondents for this study.

For survey questions related to internal aspects of the model, respondents needed to use their knowledge of integration with applications of critical value chain activities (e.g. logistics, procurement, inventory management, operations) within the business unit. For responding to questions related to external aspects of the model, we asked respondents to use their knowledge of integration with applications of external clients. While answering the questionnaire, respondents were asked to focus on their most important internal and external connections. Previous literature shows that this helps to avoid having respondents average their responses across all internal and external connections (Saraf et al., 2007; Rai and Tang, 2010). This is important because it is possible that the respondent company might have distant partners with which their connections might not be very important. Hence, it is necessary that the respondents focus on their most important connections.

Our research design is similar to previous studies with similar contexts that have used business managers as respondents for both the technical and business performance aspects of the organization. These studies (Barua et al., 2004; Rai et al., 2006; Saraf et al., 2007; Rai and Tang, 2010; Raschke, 2010) reported that managers are able to respond to technology as well as business related questions provided that the questions are not too broad and are worded at a functional level. The obvious benefit of having a single-respondent design is that there is increased likelihood of a higher response rate. In the following sections we elaborate more upon the target sample frame, sample size, and the analysis plan for the study.

5.2.3 Target Sample Frame

The target sample frame was manufacturing or operations managers in medium to large manufacturing firms of North America. Manufacturing firms are appropriate because they have a strong process-based approach in their operations and their operations interact profusely with each other as well as with outside vendors. This brings in the relational aspect that is covered in our knowledge and process constructs. In addition, such firms also have a strong IT-applications presence as most have adopted enterprise resource planning systems, which allow interactions among the units as well as with outside vendors. This is consistent with our integration constructs as it would provide the most appropriate context for our study. Thus, manufacturing or operations managers in manufacturing firms that have their operations integrated through enterprise systems would make the most appropriate sample for this study.

5.2.4 Sample Size

Choosing the right sample size is a very important aspect of research design. For this thesis, we plan to use partial least squares modeling (PLS). Heuristics suggest that for PLS, a sample size greater than ten times the maximum number of paths leading into any one construct in the structural equation should be adequate (Tabachnik and Fidell, 2007). In this study, the responding construct has the maximum number of paths leading into it, which dictates a minimum sample of 60 (6 x 10).

5.3. Assessing the Content Validity of the Measures

We assessed the content validity of the measures via two rounds of card-sorting analysis with academic expert panels (Moore and Benbasat, 1991). We also conducted a pre-test of the instrument with industry experts.

5.3.1. Card-Sorting Analysis

Two panels of academic experts were used to establish the content validity (preliminary convergent and discriminant validity) of the selected scales. The first panel, consisting of ten PhD students conducted the first round of the card sort, while the second panel, consisting of six PhD students and three associate professors, conducted the second card sort. Participants in both rounds of the card sort were provided with definitions of constructs along with a list of unsorted, selected items for the study. Participants were then asked to place the items in one of the categories (definition) that they deemed appropriate. Participants were also asked to provide any comments for items they had trouble placing or that were hard to understand or ambiguous.

To analyze the results, we examined each category to determine: (1) the number of correct item placements (hits), (2) the number of items of a category that were misplaced in other categories, and (3) the number of incorrect items that each category received. The results of both rounds of card-sort analysis can be found in Appendix 10. The analysis resulted in two main adjustments to the instrument. First, items that were found to be ambiguous (70% agreement level) were further refined to improve the clarity and comprehensiveness of the questions. The item "order changes are automatically reflected in applications of our external partners," from external electronic integration, was changed to "data related to order changes are automatically reflected in applications of our external partners" in order to improve the focus on data integration. This item did not hold well, however, in the second card sort and was eventually dropped. The item "we collaborate with our external partners to arrive at demand forecasts," from external process coupling, was changed to "to arrive at demand forecasts, we collaborate with our external partners" in order to improve consistency with other items and increase the focus on the process of demand forecasting. The agreement score of this item increased to 89% in the second round of the card sort.

Second, in the first round of card sorting, items that received an average agreement level of less than 70% were dropped. Specifically, one item from internal electronic integration and two items of external process coupling were dropped because they received average agreement scores of less than 70%. Overall, the average agreement for the constructs was 91%. In the second round of card sorting, items that received an average agreement level of less than 80% were dropped. Specifically, five items from internal electronic integration, two from external electronic integration, one from knowledge exploration, two from knowledge exploitation, and two from external process coupling were dropped because they had average agreement lower than 80%. The overall average agreement in the second round was 89%, which is a slight decrease from the average agreement level of the first round. One reason for a reduced agreement level is that the number of respondents in the second round was nine, compared to ten respondents in the first round. This could also be because the second round had senior-level professors who might have been more stringent in their item placement compared with all ten PhD students in the first round. Nonetheless, the final agreement level of 89% is satisfactory for data collection.

5.3.2. Pre-Testing of the Measurement Instrument

In addition to the card-sorting validation, we also pre-tested our survey instrument with five business unit managers. The formal designations of the managers varied, but overall, they held senior-level positions that made them responsible for business unit operations management. The participants were provided with a Web link to access the survey hosted on a website. They were asked to respond to the survey while also providing comments about each question on the survey. The primary purpose of this exercise was to assess whether the survey was understood by industry experts as intended by the researchers. Overall, the survey was found to be fairly easy to understand, with straightforward questions. Only minor adjustments were required to make sure that the unit of analysis (i.e. the business unit) was clear for the respondents. After adjusting some questions, we ran a pilot test of the survey in which we timed the participants and solicited their comments about survey understandability and flow. Similar to the participants used in the earlier pre-test, the participants in this phase were also senior-level managers responsible for business unit operations management. The number of participants was five, and there were no further changes made to the survey in this phase.

5.4. Survey Administration

The survey was administered using a Web-based survey approach where the survey is hosted on a website and participants are sent an invitation to visit the website to respond to the survey. This Web-based survey approach was primarily chosen because it is cost-effective, paperless, and easier to manage during the survey launch, data acquisition, and analysis phases (Simsek and Veiga, 2001).

Screening questions were included in the questionnaire to ensure reduced sampling error (see Appendix 11). The questions asked the respondents about their job role in their organization. Specifically, the screening questions asked whether the respondents interacted with customers and suppliers and internal stakeholders in their job. They also asked whether respondents had experience managing the operations of their business unit and whether they had knowledge about the IT systems that they used to interact with internal and external stakeholders of their business unit. These questions were used to screen out any respondents who did not meet our target sample frame. We also included several quality control questions to check that respondents were paying attention to the questions. These were primarily reverse-worded questions that tested whether the respondents are actually thinking about their answers. Respondents who were found to be straight-lining (answering all questions in the exact same way without any cognitive effort) through the questions were terminated from the survey. Moreover, controls were also set up to ensure that the same respondents did not complete the survey more than once.

The data were collected from an opt-in panel of respondents and managed by a reputable data collection company that specializes in business-to-business research and data collection. The panel of respondents is actively managed by the company using quality measures that comply with the Marketing Research Association code (e.g. limiting number of contacts, limiting number of surveys taken, and flagging and removing professional survey takers). The respondents were reached using a variety of methods to ensure the representativeness of the sample. The methods include direct opt-in requests by profile matching, email invites, and phone invites. Participants were ensured that participation in the research was purely voluntary, and they were given the opportunity to exit the survey at any point in the survey. To improve motivation to respond to the survey, the respondents were offered a summary of the analysis report as well as a monetary incentive (gift certificate, charitable donation).

We collected 303 complete responses in the final data set, which were obtained from 1222 eligible respondents who met the screening criteria. The response rate is therefore 24.7%. We did not find any evidence of non-response bias among the respondents. Non-response bias was assessed by verifying that there were no significant differences in the mean responses of early and late respondents with respect to the main constructs of the study. The early respondents were the ones who responded to the survey in the first wave of data collection whereas the late respondents were those who were re-contacted during the second phase of data collection.

5.5 Data Analysis

Although multivariate data can best be analyzed using software that allows a covariance-based structural equation modeling technique, we chose SmartPLS to do the analyses using a partial least squares (PLS) technique, for the following reasons.

First, covariance-based SEM requires a high sample size compared to PLS. For instance, for covariance-based SEM, following the ten times the number of measures rule, we would need 600+ observations for our 60+ items (Bentler and Chou, 1987). By contrast, PLS requires much lower sample sizes. There are several heuristics about this. For PLS, a sample size greater than ten times the maximum number of paths leading into any one construct in the structural equation should be adequate (Tabachnik and Fidell, 2007). The "responding" construct has the maximum number of paths leading into it, which dictates a minimum sample of 60 (6 x 10). There are other studies suggesting that sample size for PLS should be 150-200 in order to be able to detect path loadings as small as 0.20 (Chin and Newsted, 1999; Goodhue et al., 2006). Our sample size of 303, however, provides more observations than these heuristics and should be sufficient for this study.

Second, PLS has been found to perform better than covariance-based SEM techniques when data are not normally distributed (Chin, 2010; Hair et al., 2011; Ringle et al., 2012). PLS, in contrast to SEM, provides much more robust estimates while not imposing very stringent normality distribution restrictions on data (Chin, 2010). Many of our data distributions deviated from normality assumptions because they were leptokurtic and positively skewed. These were not fixed even after transformations, hence we chose PLS as our data analysis technique. All analyses were performed using the SmartPLS version 2 M3 software tool.

5.6 Results

5.6.1 Sample Characteristics

The respondents came from various subcategories of the manufacturing industry. The majority of respondents came from miscellaneous manufacturing industries (32%). The second highest percentage according to subcategory was electronics and electric equipment manufacturing (19.8%). Other subcategories of the manufacturing industry were also represented: industrial machinery and computer equipment (13.5%), fabricated metal products (8%), rubber and plastics (7%), instruments and related products (6.3%), and apparel, furniture, and transportation (about 3% each). The respondents were mostly operations managers (66.99%). There were also purchasing managers (11.55%), plant managers (5.94%), and supply chain managers (9.24%). 20.46% of the respondents indicated that they had some kind of college/technical degree, while 36% had a bachelor's degree and 36% had a master's degree. A major portion of respondents worked for large business units. 75.9% reported having revenues greater than 15 million US dollars while 10.89% had revenues between 11 and 15 million US dollars. 8.9% reported having revenues between 5 and 10 million US dollars and 4.29% reported having revenues less than 5 million US dollars. Tests of late respondents (from the second wave of data collection) and early respondents (from the first wave of data collection) showed no systematic differences. Thus, non-response bias is not expected to be a major concern. A summary of demographics for the respondents is shown in Table 5.10 below.

Table 5.10: Demographics of Participants

Demographics		Frequency	Percentage
Industry	Apparel and textile	9	3.2%
	Furniture and fixtures	10	3.3%
	Rubber and plastics	22	7%
	Fabricated metal products	24	8%
	Industrial machinery and computer equipment	41	13.5%
	Electronics and electric equipment	60	19.8%
	Transportation equipment	10	3.3%
	Instruments and related products	19	6.3%
	Manufacturing industries	97	32%
	Other	11	3.6%
Respondent Role in Organization	Operations manager	203	66.99%
	Supply chain manager	28	9.24%
	Plant manager	18	5.94%
	Purchasing manager	35	11.55%
	Other	19	6.27%
Education	High School Degree	5	1.65%
	College/Technical degree	62	20.46%
	Bachelor degree	110	36.30%
	Master degree	111	36.63%
	PhD degree	15	4.95%
Business Unit Size	Less than 5 million dollars	13	4.29%
	Between 5 and 10 million dollars	27	8.9%
	Between 11 and 15 million dollars	33	10.89%
	Greater than 15 million dollars	230	75.9%

5.6.2. Measurement Model Validation

Reliability and Validity

To ensure internal consistency of measures, we used the composite reliability scores. The composite reliability for all the constructs is above 0.7 which ensures internal consistency of the constructs. The composite reliabilities are shown in Table 5.11 below.

Table 5.11 – AVE, Composite Reliability and Cronbach's alpha

	AVE	Composite Reliability
EEI	0.649	0.928
EPC	0.684	0.929
IEI	0.504	0.802
IPC	0.578	0.872
KER	0.682	0.938
KET	0.583	0.894
MORT	0.506	0.834
RES	0.531	0.910
SEN	0.515	0.895

To assess convergent validity, we examined the standardized loadings from the PLS output. Convergent validity reflects the degree to which items load on their own construct (Straub and Boudreau, 2004). The standardized loadings should be above 0.707 for appropriate levels of convergent validity. Table 5.12 shows the loadings of all items which are above 0.707. There were a few items in some constructs, however, that had standardized loadings below the 0.707 threshold and thus they did not load very well on their respective constructs. Specifically, the first, second and sixth items from the original instrument did not load well on the internal integration construct and hence were dropped. The second item of internal process coupling did not load well and was dropped. Moreover, the fifth, third and ninth items of knowledge exploration, external electronic integration and sensing, respectively, did not load well and were dropped. Finally, the second and the seventh items of the market orientation construct also did not load well and hence were not retained. While dropping these items care was taken to make sure that the meaning of the construct does not change. There were also some items that were below the 0.707 threshold but were still retained. Specifically, IEI_5 (0.639), IPC (0.671), RES_2 (0.635), SEN_2 (0.666), SEN_4 (0.690), MORT_1 (0.589), MORT_4 (0.676), and MORT_6 (0.634) were retained. These were retained for two reasons. First, they were retained to maintain the meaning of the overall construct. Second, since the average of the remaining items for the respective constructs was above the 0.707 threshold even with these low loading items, we decided to keep these items to minimize the number of eliminated items.

Table 5.12 – Item Loading and Cross Loadings

	EEI	EPC	IEI	IPC	KER	KET	MORT	RES	SEN
EEI_1	0.817	0.388	0.249	0.205	0.536	0.524	0.211	0.404	0.385
EEI_2	0.809	0.447	0.279	0.264	0.495	0.493	0.169	0.383	0.344
EEI_4	0.756	0.446	0.223	0.138	0.441	0.404	0.148	0.310	0.302
EEI_5	0.838	0.409	0.243	0.242	0.532	0.493	0.247	0.432	0.433
EEI_6	0.805	0.433	0.226	0.239	0.540	0.550	0.141	0.459	0.374
EEI_7	0.825	0.449	0.269	0.211	0.537	0.544	0.188	0.443	0.402
EEI_8	0.788	0.427	0.264	0.238	0.464	0.493	0.171	0.395	0.375
EPC_1	0.467	0.827	0.410	0.426	0.500	0.356	0.182	0.507	0.141
EPC_2	0.438	0.831	0.409	0.463	0.447	0.389	0.139	0.526	0.097
EPC_3	0.442	0.824	0.340	0.393	0.450	0.292	0.166	0.467	0.114
EPC_4	0.418	0.839	0.358	0.435	0.468	0.365	0.184	0.523	0.107
EPC_5	0.514	0.855	0.344	0.471	0.501	0.345	0.085	0.540	0.132
EPC_6	0.341	0.784	0.369	0.482	0.412	0.279	0.021	0.469	0.075
IEI_3	0.137	0.359	0.732	0.452	0.272	0.246	0.122	0.275	0.060
IEI_4	0.186	0.480	0.744	0.499	0.259	0.213	0.049	0.389	0.032
IEI_5	0.271	0.159	0.639	0.242	0.225	0.293	0.011	0.163	0.348
IEI_7	0.322	0.220	0.721	0.333	0.258	0.318	0.023	0.187	0.405

IPC_1	0.219	0.444	0.453	0.743	0.317	0.253	0.125	0.385	0.199
IPC_3	0.212	0.360	0.390	0.760	0.282	0.213	0.130	0.302	0.061
IPC_4	0.234	0.429	0.462	0.833	0.306	0.214	0.141	0.342	0.137
IPC_5	0.189	0.390	0.444	0.784	0.268	0.188	0.117	0.320	0.112
IPC_6	0.180	0.412	0.341	0.671	0.278	0.206	0.082	0.358	0.179
KER_1	0.506	0.477	0.353	0.348	0.834	0.413	0.154	0.530	0.385
KER_2	0.525	0.464	0.308	0.296	0.814	0.345	0.092	0.447	0.312
KER_3	0.526	0.450	0.289	0.331	0.843	0.352	0.206	0.493	0.363
KER_4	0.545	0.457	0.278	0.346	0.828	0.355	0.093	0.480	0.392
KER_6	0.505	0.441	0.254	0.281	0.796	0.336	0.145	0.433	0.384
KER_7	0.525	0.477	0.286	0.285	0.833	0.367	0.116	0.488	0.392
KER_8	0.507	0.481	0.301	0.323	0.831	0.362	0.144	0.454	0.367
KET_1	0.459	0.296	0.240	0.210	0.292	0.770	0.080	0.369	0.356
KET_2	0.473	0.281	0.231	0.182	0.314	0.755	-0.040	0.276	0.332
KET_3	0.477	0.278	0.298	0.243	0.307	0.760	0.039	0.348	0.293
KET_4	0.481	0.308	0.286	0.205	0.337	0.791	0.063	0.413	0.286
KET_5	0.501	0.342	0.346	0.205	0.394	0.765	-0.038	0.408	0.310
KET_6	0.459	0.373	0.277	0.256	0.358	0.740	-0.006	0.345	0.277
MORT_1	0.106	0.082	0.074	0.120	0.074	0.029	0.589	-0.005	0.089
MORT_3	0.118	0.114	0.077	0.120	0.113	-0.022	0.750	0.125	0.054
MORT_4	0.241	0.147	0.050	0.124	0.121	0.092	0.676	0.110	0.139
MORT_6	0.078	0.090	-0.013	0.092	0.055	-0.072	0.634	0.024	0.086
MORT_8	0.186	0.117	0.071	0.119	0.164	0.007	0.873	0.184	0.139
RES_1	0.365	0.479	0.324	0.374	0.450	0.371	0.094	0.734	0.180
RES_2	0.276	0.394	0.199	0.324	0.361	0.298	0.046	0.635	0.135
RES_3	0.353	0.417	0.247	0.280	0.432	0.275	0.140	0.784	0.194
RES_4	0.408	0.399	0.265	0.312	0.450	0.288	0.118	0.701	0.188
RES_5	0.365	0.448	0.349	0.322	0.428	0.366	0.136	0.723	0.219
RES_6	0.362	0.450	0.241	0.311	0.340	0.330	0.138	0.732	0.095
RES_7	0.382	0.461	0.260	0.324	0.447	0.399	0.135	0.762	0.150
RES_8	0.330	0.405	0.223	0.275	0.379	0.309	0.068	0.702	0.165
RES_9	0.433	0.534	0.297	0.406	0.471	0.443	0.154	0.772	0.168
SEN_1	0.323	0.106	0.200	0.108	0.336	0.246	0.051	0.128	0.744
SEN_2	0.325	0.112	0.153	0.072	0.324	0.278	0.118	0.160	0.666
SEN_3	0.304	0.094	0.126	0.111	0.265	0.296	0.078	0.163	0.700
SEN_4	0.358	0.084	0.227	0.149	0.316	0.282	0.058	0.164	0.690
SEN_5	0.440	0.169	0.214	0.187	0.393	0.340	0.127	0.172	0.739
SEN_6	0.296	0.048	0.154	0.076	0.291	0.275	0.127	0.087	0.744
SEN_7	0.264	0.025	0.190	0.148	0.288	0.299	0.153	0.169	0.740
SEN_8	0.328	0.119	0.265	0.181	0.345	0.291	0.140	0.256	0.713

Moreover, convergent validity is also assessed at the construct level by checking the average variance extracted (AVE) of each reflective construct. A value of 0.50 would show that more than half the variance of the construct is explained by its own items (Ringle et al., 2012). Table 5.11 (above) shows that all constructs have an AVE value above 0.50 thus indicating convergent validity.

To assess discriminant validity of constructs we verified that items load strongly on their focal construct as compared to the other constructs in the model. This was assessed at the item level using the Fornell-Larcker approach (Fornell and Larcker, 1981) and at the construct level using the outer model loadings (Chin, 2010). At the item level we verified that each item has a higher loading with its own construct as compared to its loading with the other constructs. Table 5.12 (above) shows that this is the case for all items and that each item is loaded to its own construct more than it did with the other constructs. At the construct level, we verified that the correlations between constructs are lower than the square root AVE of the focal construct. This is shown in table 5.13a.

Table 5.13a – Latent Variable Correlations

	EEI	EPC	IEI	IPC	KER	KET	MORT	RES	SEN
EEI	**0.806**								
EPC	0.532	**0.827**							
IEI	0.311	0.449	**0.710**						
IPC	0.273	0.537	0.554	**0.760**					
KER	0.629	0.562	0.358	0.383	**0.826**				
KET	0.622	0.410	0.369	0.284	0.438	**0.764**			
MORT	0.226	0.159	0.077	0.158	0.165	0.022	**0.711**		
RES	0.503	0.612	0.370	0.450	0.576	0.475	0.159	**0.729**	

SEN	0.465	0.136	0.269	0.183	0.450	0.404	0.151	0.229	**0.718**

Moreover, the AVE value for non-associated items, which quantifies the amount of variance a construct measure captures from the items it is not associated with relative to the amount due to measurement error, was lower than significantly lower than the AVE for associated items for each construct (see Table 5.13b). This result further confirmed construct validity (Fornell & Larcker, 1981).

Table 5.13b

	AVE (associated items	AVE (non-associated items)
EEI	0.649	0.154
EPC	0.684	0.141
IEI	0.504	0.088
IPC	0.578	0.091
KER	0.682	0.153
KET	0.583	0.123
RES	0.531	0.143
SEN	0.515	0.074

As all tests meet the suggested guidelines, we conclude that the constructs have convergent and discriminant validity. In addition, we also tested for multicollinearity between all the construct indicators. The values for the variance inflation factors (VIF) were found to be well below the 10.00 (Hair et al., 2009) and even the more stringent 3.33 thresholds.

5.6.3. Testing the Structural Model

The research model was tested using SmartPLS 2.0. Significance levels were attained performing 500 bootstrapped iterations with subsamples of 250 cases (Chin, 1998). Figure 1 shows the path coefficients and the variance explained (R^2 coefficient of determination) in the endogenous constructs.

The structural model was assessed using the variance explained in the dependent variables (R^2), path coefficients (β) and their levels of significance. As shown in figure 1, all hypotheses were supported at the 0.001 level, except for H5 which was not supported. Internal electronic integration was found to be positively associated with knowledge exploitation (H1: β = 0.368, t = 5.900) and internal process coupling (H4: β = 0.554, t = 11.927). Knowledge exploitation was found to be positively associated with sensing (H2: β = 0.262, t = 3.399) and responding (H3: β = 0.197, t = 3.350). External electronic integration was found to be positively associated with external process coupling (H6: β = 0.532, t = 7.005) and knowledge exploration (H8: β = 0.629, t = 11.220). External process coupling was found to be positively associated with responding (H7: β = 0.313, t = 4.415). Finally, knowledge exploration was found to be positively associated with sensing (H9: β = 0.319, t = 4.408) and responding (H10: β = 0.261, t = 4.147). None of the control variables (market orientation and business unit size) were found to have a significant effect on the two dependent variables. Overall, the model explains 49.8% of variance in the responding construct and 26.4% of variance in the sensing construct.

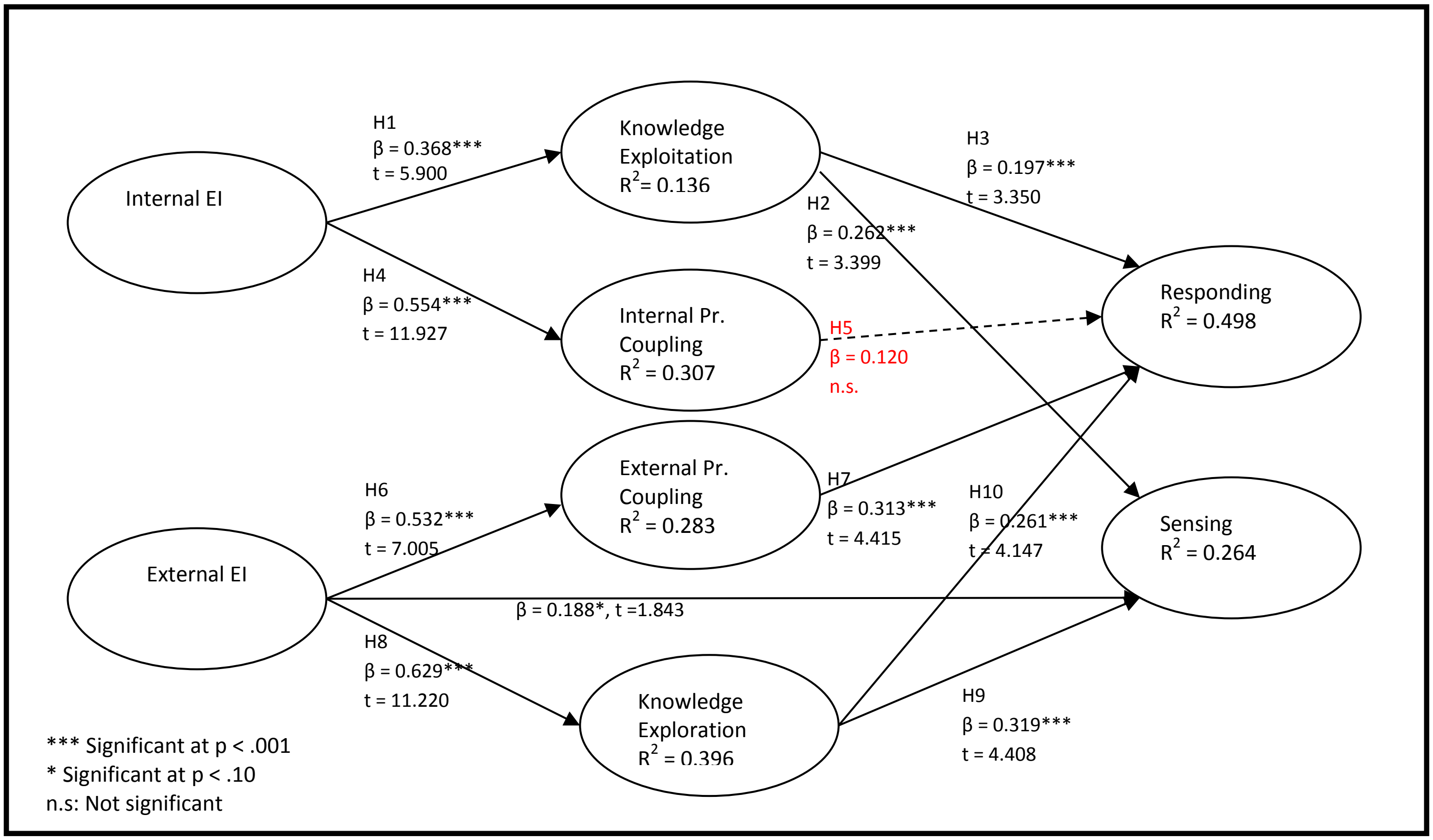


Figure 5.1: Path Coefficients and Variance Explained

Mediation Analysis

To test the effect of the mediator variables, we employed the Barron and Kenny (1986) approach. Using this approach, we tested for significance of the independent variable on the dependent variable (without the mediator). Then we added the mediator and tested whether the entire indirect path was significant (i.e. IV →Mediator and Mediator → DV) while controlling the direct effect of the independent variable on the dependent variable. Then, we assessed whether the direct effect of the independent variable diminished (or disappeared entirely) due to the addition of the indirect path. If this was the case, we concluded that mediation is present in the relationship. Also, since several of the relations are mediated by multiple mediators we made sure to systematically remove the other mediators in the relation when testing the mediating effect of a specific mediator.

Our model has six mediated paths in total. We started with the relation between internal electronic integration and responding mediated by knowledge exploitation. We first established that internal electronic integration has a significant direct effect on responding ($\beta = 0.187$, $t = 2.055$). Then we tested the indirect relation from internal electronic integration to the mediator variable knowledge exploitation ($\beta = 0.381$, $t = 6.947$) and from knowledge exploitation to responding ($\beta = 0.193$, $t = 2.777$). This was done after removing the other mediator (internal process coupling) from the model since we wanted to assess the effect of only one mediator at a time. The direct effect between internal electronic integration and responding became insignificant ($\beta = -0.030$, $t = 0.394$), after the inclusion of the mediator variable knowledge exploitation. Since both the paths in the indirect path are significant, we conclude that knowledge exploitation fully mediates the relation between internal electronic integration and responding.

Next, the mediation effect of internal process coupling in the relation between internal integration and responding was tested with knowledge exploitation removed from the model. The direct path between internal integration and responding without any mediators in the model was significant ($\beta = 0.187$, $t = 2.055$). After adding internal process coupling, the path between internal integration and internal process coupling was significant ($\beta = 0.552$, $t = 10.463$) but the path between internal process coupling and responding was not significant ($\beta = 0.126$, $t = 1.453$).

Since the indirect path (i.e. IEI → IPC and IPC → RES) was not significant, we conclude that there is no mediation through internal process coupling in the relation between internal electronic integration and responding.

The relation between internal electronic integration and sensing was found to be mediated by knowledge exploitation. The direct effect between internal electronic integration and sensing was not significant (β = 0.072, t = 0.973). The indirect path, however, was significant as the effect from internal electronic integration to knowledge exploitation was significant (β = 0.373, t = 5.959) and so was the effect from knowledge exploitation to sensing (β = 0.155, t = 1.705) at the 0.10 level.

The direct effect between external electronic integration and responding without any mediators in the relation was found to be significant (β = 0.433, t = 6.269). However, with electronic process coupling added as mediator, the direct effect diminishes and becomes non-significant (β = 0.020, t = 0.255). The indirect path, consisting of external electronic integration to external process coupling (β = 0.531, t = 7.056) and from external process coupling to responding (β = 0.311, t = 4.323) are both significant. Thus, we conclude that external process coupling fully mediates the path between external electronic integration and responding. With only knowledge exploration added as mediator, the direct effect diminishes and becomes non-significant (β = 0.023, t = 0.288). The indirect path, from external electronic integration to knowledge exploration (β = 0.631, t = 11.499) and from knowledge exploration to responding (β = 0.254, t =

3.131) are both significant. Hence, we conclude that knowledge exploration fully mediates the relation between external electronic integration and responding.

Finally, knowledge exploration was found to partially mediate the relation between external electronic integration and sensing. The direct path without knowledge exploration as mediator was significant (β = 0.433, t = 3.131). When knowledge exploration is added the direct effect reduces in strength but remains significant (β = 0.188, t = 1.843) at the 0.10 level. The indirect path, consisting of the paths from external electronic integration to knowledge exploration (β = 0.630, t = 11.245) and from knowledge exploration to sensing (β = 0.222, t = 2.570), are significant. The results of mediation analysis using the Barron and Kenny (1986) approach are shown in Table 5.14.

Table 5.14: Mediation Analysis Results (using Barron and Kenny (1986) approach)

Relationship	**Direct without Mediator** (β)	**Direct w Mediator** (β)	**Conclusion**
IEI → KET → RES	0.187 (significant)	-0.030 (not significant)	Full mediation since the indirect path is significant while the direct path becomes insignificant.
IEI → IPC → RES	0.187 (significant)	-0.008 (not significant)	No mediation, only direct effect without mediator is significant.
IEI → KET → SEN	0.206 (significant)	0.088 (not significant)	Full mediation since the indirect path is significant while the direct path becomes insignificant.
EEI →EPC →RES	0.433 (significant)	0.020 (not significant)	Full mediation since the indirect path is significant while the direct path becomes insignificant.
EEI → KER →RES	0.433 (significant)	0.023 (not significant)	Full mediation since the indirect path is significant while the direct path becomes

			insignificant.
EEI →KER →SEN	0.390 (significant)	0.188 (significant)	Partial mediation as the direct effect remains significant at the 0.10 level while the indirect path is also significant.

We also performed mediation analysis using the bootstrap method (Preacher and Hayes, 2008). In this method the bootstrapped coefficients of the direct and indirect paths are compared. Similar to the Barron and Kenny (1986) approach, we systematically removed the mediators for paths with multiple mediators to test the effect of a particular mediator. To test mediation, we compared the bootstrapped path coefficient of the direct path with the bootstrapped path coefficient of the indirect path. If the direct is insignificant while the indirect path is significant, we conclude in favor of mediation. The results of this test were similar to those attained from Barron and Kenny (1986) approach detailed above. The results of the bootstrap approach are shown in Table 5.15 below.

Table 5.15: Mediation Analysis Results (using bootstrap approach)

Relationship	Direct Path	Indirect Path	Conclusion
IEI → KET → RES	β =-0.0303, t=0.4062	β =0.0713, t=2.4261	Since the direct path is nonsignificant and indirect is significant, this is mediation
IEI → IPC → RES	β =-0.0082, t=0.1093	β =0.0613, t=0.9482	Since both paths are insignificant, there is no mediation
IEI → KET → SEN	β = 0.155, t=1.2313	β = 0.1457, t= 2.0047	Since the direct path is nonsignificant and indirect is significant, this is mediation

EEI →EPC →RES	β =0.0203, t=0.2446	β =0.1852, t=2.0554	Since the direct path is nonsignificant and indirect is significant, this is mediation.
EEI → KER →RES	β =0.0234, t=0.2807	β =0.1836, t=2.6497	Since the direct path is nonsignificant and indirect is significant, this is mediation.
EEI →KER →SEN	β =0.1900, t=1.7381	β =0.3298, t=3.5633	Shows partial mediation. The indirect path is significant at .01 level and the direct path is significant at the .10 level.

Common Method Bias

Using a single respondent to provide responses to both independent and dependent variables raises some concerns of common method bias. There were several steps taken to reduce this adverse effect. At the design stage, we made sure that the dependent and independent variable questions were not located close together on the survey. This reduces the possibility that respondents would try to match their responses on the IV and DV sides of the questions (Podsakoff et al., 2003). We also made sure to maintain respondent anonymity, thereby reducing the feeling of evaluation apprehension so that respondents do not provide answers based on how they think the researcher would want them to respond on the survey questions (Podsakoff et al., 2003). Participants were made aware in the invitation letter that the research was being conducted by a reputable research university following all research ethics guidelines and that their identity would not be associated with the responses in any way, thus maintaining total anonymity of respondents. Moreover, it has also been suggested that the effects of common method bias can be reduced by careful construction of the survey instrument (Tourangeau et al., 2000). We ensured careful construction of the instrument by strictly following suggested guidelines and evaluating the instrument through several pretests prior to its use (Podsakoff et al., 2003). After collecting the data, we used Harman's single-factor test to evaluate whether common method bias was a concern in the data. The test resulted in the emergence of eight factors with the highest factor contributing 30% of the total variance explained. Since a single factor did not account for the major part of the variance, these results suggest that common method bias is unlikely to be a cause for concern in this study (Pavlou and El Sawy, 2006).

Post-hoc Analysis:

Agility literature suggests that sensing and responding are important components of agility (Sambamurthy et al., 2003). It can be argued that sensing is required in order to be able to respond to change. The basic reasoning is that organizations need to be able to detect changes before they are able to respond to change. Although this argument does make sense, the main focus of this thesis was not to investigate how sensing and responding are related. Several studies suggest that sensing and responding do not necessarily covary (Nazir and Pinsonneault, 2012) and that it is not necessary that organizations which sense change are necessarily able to respond to change also (Overby et al., 2006). However, as a post-hoc analysis we checked the relation between sensing and responding. We did not find a significant effect between sensing and responding. This obviously is a relation which needs further investigation to improve our understanding of how sensing and responding are related. Future studies should focus upon delving deeper into this relation.

Summary of Results:

Overall, we have found strong support for all the hypotheses except for the relation between internal process coupling and responding (see Table 5.16 for a summary of results). The overall conclusion of mediation analysis from the two tests is that knowledge exploitation fully mediates the relation between internal electronic integration and responding as well as internal integration and sensing. Internal process coupling does not have any mediation effects. External process coupling fully mediates the relation between external electronic integration and responding. Also, knowledge exploration fully mediates the relation between external electronic integration and responding but partially mediates the relation between external electronic integration and sensing.

Table 5.16: Summary of Results

No.	**Hypothesis**	**Result**
H1	Internal EI → Knowledge Exploitation	Supported
H2	Knowledge Exploitation → Sensing	Supported
H3	Knowledge Exploitation → Responding	Supported
H4	Internal EI → Internal Process Coupling	Supported
H5	Internal Process Coupling → Responding	Not supported
H6	External EI → External Process Coupling	Supported
H7	External Process Coupling → Responding	Supported

H8	External EI → Knowledge Exploration	Supported
H9	Knowledge Exploration → Sensing	Supported
H10	Knowledge Exploration → Sensing	Supported

CHAPTER SIX

DISCUSSION, CONTRIBUTIONS AND CONCLUSION

6.1 Discussion

This study aspired to better understand how integration affects the sensing and responding capabilities of businesses. We found strong support for all but one hypothesis. Consistent with the proposed model, we found that the two types of integration (internal and external) have differential impacts on the sensing and responding capabilities of agility. Internal electronic integration positively affects the responding and sensing capabilities through the mediating effect of knowledge exploitation. This is consistent with coordination theory, which specifies that organizations that communicate and share knowledge internally are able to adjust dynamically and respond to environment changes because this coordination mechanism enables managing exceptions and unplanned changes (March and Simon, 1958). Under such circumstances, organizational units need to communicate and share knowledge to sense changes and cope with changing situations because dependencies among units can no longer be managed in a programmed way (Bailey et al., 2010; Espinosa et al., 2002; March and Simon, 1958). The mediation effect of knowledge exploitation diminishes the direct effect (i.e., brings to non-significant direct path) and thus we concluded that knowledge exploitation fully mediates the two relationships. This finding is consistent with the previous literature. For instance, studies have reported that sharing knowledge within the organizational unit fosters a learning environment (Braunscheidel and Suresh, 2009; Gunasekaran et al., 2008). When knowledge is shared internally, units become aware of opportunities and can gain business insights related to process and product improvements (Hoyt et al., 2007; Im and Rai, 2008).

We did not find any support for the proposed effect of internal integration on responding through internal process coupling. Although the study shows that internal electronic integration leads to higher process coupling, we did not see those effects transfer to responding capability. The reasons for not finding this effect are not clear. Some previous literature has also reported not finding any effect of process coupling on business unit performance (Saraf et al., 2007). Although the theoretical argument that process coupling would improve the responding capability of business units makes much sense, there is a need to take a deeper look into this phenomenon to better understand how this effect unfolds. Some previous research has reported that excessively streamlining process activities can lead to highly routinized processes and this might be one reason why process coupling fails to positively affect responding capability (Bharadwaj, 2000). Moreover, it is also possible that tight process coupling results in some marginal adjustments to incremental changes in the environment but lacks the capability to provide any major adjustments to radical changes in the environment (Gibson and Birkinshaw, 2004).

We found strong support for the effect of external electronic integration on responding capability through both external process coupling and knowledge exploration. Both mediating variables fully mediate the relation between external electronic integration and responding. This is consistent with the idea that, in addition to the dynamic adjustment mechanism of knowledge exploration, the advanced structuring mechanism of process coupling is also important in providing the capability to respond to environmental change (Braunscheidel and Suresh, 2009; Gunasekaran et al., 2008; Hoyt et al., 2007; Vazquez-Bustelo et al., 2007). IS-enabled integration allows business units to engage in boundary spanning activities and allows for the transfer of knowledge and expertise with external contacts of the business unit (Carlile, 2004; Malhotra et al., 2007). Moreover, businesses are able to respond better due to tight process coupling with external partners. This streamlines operations and coordinates activities that are required in order to respond (Im and Rai, 2008). When businesses communicate with their external partners and have tight process coupling with them, there is a greater chance that they will be better able to adapt to changes since they will have information and capability to respond through a larger spectrum of responses (Gosain et al., 2005; Malhotra et al., 2007).

Furthermore, our findings support the idea that external electronic integration helps the sensing capability of business units and this effect is transferred directly as well as with the help of knowledge exploration. The support for both direct and indirect effects is interesting; it means that business units are able to sense changes in the environment by going through the process of gaining electronic integration as well as when they formally make the effort to explore the knowledge that is embedded with their partners. It is possible that electronic integration with external partners has the potential to directly affect the sensing capability of the business unit because it can expand their understanding of the different ways other businesses may run their business activities. This can sensitize the focal business units to new opportunities and new technologies that may be employed in their business environment. Furthermore, the focal business unit can formally engage in gaining new knowledge through facilitating the communication of new knowledge related to products or services as well as to the market environment. This knowledge exchange can be achieved by sharing information that is broad-ranging and of high quality, and that allows for sharing deep coordination-related knowledge (Gosain et al., 2005).

Overall, our study shows that internal and external electronic integration have a strong effect on the sensing and responding capabilities of business units and that this effect is enabled through the advanced structuring mechanism of process coupling as well as the dynamic structuring mechanisms of knowledge exploration and knowledge exploitation.

6.2. Contributions

This study contributes to the integration-agility literature in three ways. First, it contributes by investigating integration's impact on a non-operational performance outcome. Previous research has primarily studied the impacts of integration on operational firm outcomes such as increased sales (Mukhopadhyay and Kekre, 2002), number of policies sold (Venkatraman and Zaheer, 1990), operating costs and shipment errors (Srinivasan et al., 1994), and different process efficiency measures (Barki and Pinsonneault, 2005). In hypercompetitive environments, it is much more important to investigate how organizational units can achieve responsiveness to change rather than mere improvements in operational outcomes. By investigating the effects of integration on sensing and responding capabilities, this study addresses that gap.

Moreover, this study extends Sambamurthy et al.'s (2003) work by enhancing our understanding of the broader IT-agility relation. Although the broad IT-agility relation is important, there is a greater need to understand which specific elements of IT are helpful in achieving agility (Overby et al., 2006). This research is a first step in that direction because it clarifies the relation between one specific IT characteristic – its integrational capability – and agility. Moreover, previous research has focused primarily on responding capability as a proxy for the agility construct. The literature tells us that both sensing and responding are important capabilities that together make up the agility construct, and that they do not necessarily covary (Nazir and Pinsonneault, 2012; Overby et al., 2006). It is therefore important to study the integrational impacts on the two capabilities separately. This is an important contribution of this study to the agility stream of research.

Finally, the extant literature has lagged in specifying how exactly the enabling effect of integration on sensing and responding capabilities unfolds. Our study opens up this black box of the mediating variables that inform the integration-agility relation. Using a coordination theory perspective, we have employed the notions of advanced structuring and dynamic adjustment to investigate the mediating variables that transfer the effects of integration to sensing and responding capabilities. In essence, our proposed model delineates the individual effects of two types of integration on the individual sensing and responding elements of agility through specific knowledge and process constructs. This enables us to contribute to the extant literature on digital options by further clarifying their role. Our study provides strong support for the argument that integration has a positive effect on sensing and responding capability through the mediating effect of the knowledge and process constructs.

In summary, this study helps understand the relationship between integration and agility by highlighting the role of the mediating variables. We have argued and found support for the idea that electronic integration has a positive effect on both of the elements of agility and that this effect unfolds through the knowledge and process constructs. Indeed, the study helps to delineate *how* the effect of IT-enabled integration unfolds on the two elements of sensing and responding by clarifying the mediating effects of the process and knowledge constructs.

6.3. Limitations

This study has some limitations that must be noted. First, a limitation of our study design is that there is a single respondent answering both the independent and dependent variable questions. The major concern is whether one person in an organization is able to adequately answer the questions relating to all our constructs. This is a valid concern but is not a fatal flaw in the study design. Similar studies suggest that if the questions on the technology side are well chosen and are not worded in a highly technical manner, business managers are capable of responding to them adequately (Rai and Tang, 2010). Saraf et al. (2007) report that keeping questions at a functional rather than at a technical level allows respondents in the business domain to adequately respond to IT-related questions. We aimed at having all the IT-related questions worded in a functional manner. For instance, the integration-related questions asked about the degree to which orders, plans, schedules, part numbers, and product numbers are shared across applications and not about the technical details of *how* applications are integrated. This enables the respondent from a business domain to leverage their functional knowledge in answering technology-related questions.

Second, using a single respondent to provide responses to both independent and dependent variables raises some concerns of common method bias. This is limitation of this study. However, we have taken several steps to reduce the effects of common method bias. At the design stage we made sure not to keep the dependent and independent variables close together on the survey to reduce the possibility that respondents would be able match their responses on the IV and the DV sides of the questions. We also assured participants that the study was conducted by a reputable research university maintaining full anonymity of responses to allay concerns for evaluation apprehension. Finally, after data collection, we used Harman's single-factor test to evaluate whether common method bias was a concern. The results that have been presented in the analysis section show that since a single factor did not account for the major part of the variance, common method bias is not likely to be a cause for concern in this study (Pavlou and El Sawy, 2006). Although common method bias cannot be completely ruled out, careful construction of the survey instrument and results of the Harman's single-factor test seem to indicate that the results are not an artifact of the instrument but are an actual depiction of the relationships between constructs. To further strengthen confidence in the results and obtain generalizable results, however, future works should investigate the integration-agility relation using a multiple-respondent survey design.

Third, since the hypothesis regarding the relation between internal process coupling and responding was not supported, this can be subjected to further investigation in future studies. Although the link has strong theoretical support, the empirical results have shown some mixed findings about process coupling and performance variables such as responding capability and business unit performance (Saraf et al., 2007). Further investigation is needed to better understand the effects of process coupling.

6.4. Future Research

Although this research makes several important contributions, there are other avenues of research that should be explored by future research. First, while the cross-sectional design of this study does show relationships between constructs of interest, it does not necessarily show causation. Future research should use a longitudinal design to test the effects of integration over time. A longitudinal design will be much more conducive to detecting integrational impacts on agility over time while controlling for past effects caused by other phenomena. Moreover, since integration between internal and external members of the value chain is often developed over time, it will be fruitful for future research to explore the process of how organizations develop integration within internal units and external partners using a longitudinal design.

Second, future research should aspire to explore the integration-agility relation by focusing not only on manufacturers, as was done in this study, but also on suppliers and partners. Data should be collected from multiple sources such as manufacturers, suppliers, and customers that are involved in the supply chain relationship. This will enable us to better understand the integrational benefits from several different perspectives and we would also gain the benefits of triangulating data from several sources. Data triangulation enhances the validity of findings and presents the opportunity to create innovative ways to understand a phenomenon, reveal unique findings, challenge or integrate existing theories, and provide a clearer understanding of the problem (Thurmond, 2001).

Third, there is tremendous potential for extending this model to other contexts. This study focused on investigating integrational impacts on agility in the manufacturing industry. Integration and agility have also become extremely important in contexts such as global supply chains and healthcare. The healthcare industry, for instance, is ripe with opportunity for research regarding how different healthcare providers integrate with each other while keeping patient information confidential as well as how these partners tightly couple processes and share knowledge while using this high level of integration to gain the capability to sense and respond to changes in the way patient care is provided.

Fourth, future research can extend this study by including other important antecedents of agility. For instance, one important construct is the flexibility that is incorporated into information systems. Overall, it measures how flexible the linkages between applications are and how easily they can be changed to include new connections (Byrd and Turner, 2000; Duncan, 1995). Flexibility incorporates the extensibility and reusability that is embedded into systems. Extensibility measures the degree to which changes can be rapidly incorporated into systems (Saraf et al., 2007). The extent to which reusable modules are used in application development is also important for flexibility in the applications (Byrd and Turner, 2000). A high degree of flexibility may enable businesses to rapidly deploy new functionality into systems by using existing modules and consequently spending less time on application development. Overall, this flexibility has the potential to enable organizations to adapt processes quickly so that they can be used to respond to change without much penalty of cost and time.

Fifth, research should explore the integration-agility relationship using theoretical lenses other than the coordination theory perspective. Coordination theory does not capture all the dynamics of inter-organizational relations. One interesting avenue is the transaction cost economics perspective. According to the transaction costs perspective, every transaction in an economic system carries some unwanted costs which are analogous to friction in the physical system (Williamson, 1985). The greatest source of transaction costs is the degree to which assets of parties to a relationship are specialized to the transaction, otherwise known as asset specificity. Assets created and implemented for a particular use lose the ability to be easily transferred to other purposes. Thus, investments in collaborative mechanisms like inter-organizational systems and supply chain systems may reduce a firm's ability to be agile. With investments in idiosyncratic assets, the specificity of the assets may subvert attempts to seek alternatives or sever existing inter-organizational relationships in order to adapt to changing requirements due to lock-in effects (Young-Ybarra and Wiersema, 1999). Thus, as per the transaction costs perspective, IT-enabled integration may, in fact, lead to reduced agility in firm processes. Therefore, it is important to investigate the effects of transaction costs in the integration-agility relationship.

Finally, future research can further investigate the reasons for the lack of any effect of process coupling on the responding capability of agility. One way of investigating this phenomenon may be to assess responsiveness to changes that are incremental versus changes that are radical in nature (Gibson and Birkinshaw, 2004). It is possible that tight process coupling may enable adjustment to incremental changes but not radical changes. Splitting the responsiveness construct into responsiveness to incremental and radical changes may enable a fine-grained understanding of the agility construct and may lead to deeper insights into the integration-agility relationship.

6.5 Conclusion

This thesis attempts to understand the relationship between IT-enabled integration and business unit sensing and responding capabilities. Given the growing importance of these constructs, an investigation of the relationship between them is highly pertinent. The current hypercompetitive environment necessitates that firms pursue agility as well as tight integration. However, pursuing these objectives without understanding how one is affected by the other might prove detrimental. Our work has attempted to fill this important gap in the literature. We have presented a fine-grained understanding of this relationship by conceptualizing agility as consisting of two elements – sensing and responding. By differentiating between the two elements of agility and using more specific IT constructs (internal and external integration), our paper clarifies what the effect is and *how* it unfolds.

Using coordination theory as our theoretical lens, we have argued that the effect of internal and external integration transfers to the sensing and responding capabilities of business units through the tight streamlining of processes and sharing of knowledge with internal and external stakeholders. Using knowledge exploration, knowledge exploitation, and process coupling as mediating variables, our paper teases out the enabling effect of IT-enabled integration on agility. The paper provides a foundation for further exploration of the link between IT-enabled integration and agility.

APPENDIX 1. Measures for Internal Electronic Integration

Reference	Original Item	Adapted Item	Reason for Adaptation or Deletion
Saraf et al. (2007) Composite Reliability = 0.897	Data are entered only once to be retrieved by most applications of our channel partners.	Data are entered only once to be retrieved by most applications.	Change of context from channel partners to internal units.
	We can easily share our data with our channel partners.	We can easily share our data with each other	Change of context from channel partners to internal units.
	We have successfully integrated most of our software application with the ones of our channel partners	We have successfully integrated most of our IT applications.	Change of context from channel partners to internal units.
	Most of our software applications work seamlessly across our channel partners	Most of our applications work seamlessly across units.	Change of context from channel partners to internal units.
	Software applications on multiple machines of multiple vendors are inter-operable with each other across our channel partners	Not applicable	This item measures inter-operability *among* vendors. This is not part of our construct.
Rai et al. (2006) Composite Reliability = 0.80	Automatic data capture systems are used (e.g., bar code) across the supply chain.	Not applicable	This item is particular to SC context and refers to an aspect (automatic data capture) which is not consistent with our context
	Definitions of key data elements (e.g., customer, order, part number) are common across the supply chain.	Definition of key data elements (e.g. customer, order, part number) are common across IT applications	Changing context from SC to internal units
	Same data (e.g., order status) stored in different databases across the supply	Same data (e.g. order status) are stored consistently across IT	Changing context from SC to internal units

Reference	Original Item	Adapted Item	Reason for Adaptation or Deletion
	chain is consistent.	applications.	
	Supply chain planning applications (e.g., demand planning, transportation planning, manufacturing planning) communicate in real time.	Our planning applications communicate seamlessly with other units (e.g. demand planning, transactional planning, manufacturing planning)	Changing context from SC to internal units
	Supply chain transaction applications (e.g., order management, procurement, manufacturing and distribution) communicate in real time.	Our transactional applications communicate seamlessly with other units (procurement, manufacturing, distribution)	Changing context from SC to internal units
	Supply chain applications communicate in real time with internal applications of our organization (such as enterprise resource planning)	Not applicable	This item is not relevant for our construct as it measures the extent to which external applications communicate with internal units. Our construct is about the extent of integration of the focal unit with other internal value chain units.
	Customer relationship applications communicate in real time with internal applications of our organization.	Not applicable	This item is not relevant for our construct as it measures the extent to which CRM applications communicate with internal applications. Our construct is about the extent of integration of the focal unit with other internal value chain units.
Barua et al. (2004) Composite Reliability = 0.83	Data can be easily shared among various internal systems	Not applicable	This item is similar to another item, hence I am not including it.
	Order changes are automatically reflected in downstream processes or	Order changes are automatically reflected in	Asking about processes in the context of applications might confuse the context of the

Reference	Original Item	Adapted Item	Reason for Adaptation or Deletion
	systems	all IT applications.	construct. Hence, I have removed "processes" from this item to match my context.
	Our systems can easily transmit, integrate and process data from suppliers/vendors and customers	Our applications easily transmit, integrate, and process data among each other.	Our context is internal units, hence I have changed this item to reflect integration among applications of internal units.
	Our systems allow continuous monitoring of order status at various stages in the process	Not applicable	This item is redundant with several other items. These items already tap into the system's ability to monitor, transmit, and process data.
	Employees can easily retrieve information from various databases for decision support	Not applicable	This item is not relevant to our context as it measures the extent to which employees can easily retrieve information for decision support purposes.
Huo (2012)	All our internal units from raw material management through production, shipping, and sales are connected and integrated in real-time.	Retained as is	
	Our logistics-related operating data are searchable in real-time.	Retained as is	
	Our inventory data are searchable in real-time.	Retained as is	

APPENDIX 2. Measures for External Electronic Integration

Reference	Original Item	Adapted Item	Reason for Adaptation or Deletion
Saraf et al. (2007) Composite Reliability = 0.897	Data are entered only once to be retrieved by most application of our channel partners.	Data are entered only once to be retrieved by most applications	Changing context from channel partners to external partners.
	We can easily share our data with our channel partners.	We can easily share our data with our external partners.	Changing context from channel partners to external partners.
	We have successfully integrated most of our software application with the ones of our channel partners	We have successfully integrated most of our applications with the applications of our external partners.	Changing context from channel partners to external partners.
	Most of our software applications work seamlessly across our channel partners	Most of our applications work seamlessly with the applications of our external partners.	Changing context from channel partners to external partners.
	Software applications on multiple machines of multiple vendors are inter-operable with each other across our channel partners	Not applicable	This item measures inter-operability *among* vendors. This is not part of our construct since we are not concerned how well external partners communicate with each other.
Rai et al. (2006) Composite Reliability = 0.80	Automatic data capture systems are used (e.g., bar code) across the supply chain.	Not applicable	This item is particular to SC context and refers to an aspect (automatic data capture) which is not consistent with our context
	Definitions of key data elements (e.g., customer, order, part number) are common across the supply chain.	Definition of key data elements (e.g. customer, order, part number) are common among our applications and the applications of our external	Changing context from SC to integration between focal unit and external partners

Reference	Original Item	Adapted Item	Reason for Adaptation or Deletion
		partners.	
	Same data (e.g., order status) stored in different databases across the supply chain is consistent.	Same data (e.g. order status) stored in different databases are consistent across our applications and those of external partners.	Changing context from SC to integration between focal unit and external partners
	Supply chain planning applications (e.g., demand planning, transportation planning, manufacturing planning) communicate in real time.	Our internal applications (such as our enterprise resource planning application) communicate in real time with the applications of external partners.	Changing context from SC to integration between focal unit and external partners
	Customer relationship applications communicate in real time with internal applications of our organization.	Customer and supplier relationship applications communicate in real time with internal applications of our unit.	Changing context from SC to integration between focal unit and external partners
Barua et al. (2004) Composite Reliability = 0.83	Data can be easily shared among various internal systems	Not applicable	Similar to another item, hence not included.
	Order changes are automatically reflected in downstream processes or systems	Order changes are automatically reflected in applications of our external partners.	Asking about processes in the context of applications might confuse the context of the construct. Hence, I have removed "processes" from this item to match my context.
	Our systems can easily transmit, integrate and process data from suppliers/vendors and customers	Our systems can easily transmit, integrate, and process data from external partners.	
	Our systems allow continuous monitoring of order status at various stages	Not applicable	This item is redundant with several other items. These items already tap

Reference	Original Item	Adapted Item	Reason for Adaptation or Deletion
	in the process		into the system's ability to monitor, transmit, and process data.
	Employees can easily retrieve information from various databases for decision support	Not applicable	This item is not relevant to our context as it measures the extent to which employees can easily retrieve information for decision support purposes.

APPENDIX 3. Measures for Knowledge Exploration

Reference	Original Item	Adapted Item	Reason for Adaptation or Deletion
Malhotra et al. (2007)	Extent to which you exchange details of upcoming product or service-related changes with partner company	Extent to which we obtain details of upcoming product related changes from external partners	Adapted slightly to stress partners external to the value chain.
	Extent to which you exchange future plans such as promotion and marketing plans, long-term production plans, capital investments, and capacity utilization with partner company.	Extent to which we obtain knowledge of future plans such as promotion and marketing plans, capacity utilization from external partners	I dropped some of the terms, such as capital investments, long-term plans, as they are not relevant to our context.
	Extent to which you exchange information related to market demand trends and forecasts with partner company.	Extent to which we obtain knowledge related to demand trends and forecasts from external partners	Slightly adapted to stress partners external to the value chain.
	Extent to which you exchange information on demand shifts and changes in customer preferences with partner company.	Extent to which we obtain knowledge of demand shifts and changes in customer preferences from external partners	Slightly adapted to stress partners external to the value chain.
	Extent to which we obtain knowledge from external partners that helps us analyze and redesign processes linked to channel partners to improve the performance of the channel as a whole.	Retained as is	Retained as is
	Extent to which you exchange information related to changes in	Extent to which we obtain details of changes in product	Slightly changed to stress partners external to the value chain.

Reference	Original Item	Adapted Item	Reason for Adaptation or Deletion
	product features or volumes with partner company.	features or volumes from external partners	
	Extent to which we obtain knowledge from external partners that helps us better understand the capabilities and intentions of competitors	Retained as is	
Im and Rai (2008) Composite Reliability = 0.97	Our companies exchange knowledge about innovation opportunities that involve significant risk and uncertainty.	Extent to which we obtain new knowledge from external partners to help in building new products.	The original item is broad and asks about innovation in general. I adapted this to refer to product and services of the firm as that is more appropriate to our context. Moreover, the original item focuses on risk and uncertainty. This is not relevant to our context and hence I removed it from the item.
	Our companies exchange knowledge related to experimentation for new business opportunities.	Extent to which we obtain knowledge about new business opportunities from external partners.	Adapted the original item to refer to new business opportunities and not specifically to experimentation.
	Our companies exchange knowledge related to strategies for long-term success.	Not applicable	Long-term success is particular to original item's context and not relevant for our context. Hence this item is not retained
	Our companies exchange novel ideas for the long-term success of the relationship.	Not applicable	Long-term success is particular to original item's context and not relevant for our context. Hence this item is not retained
	Our companies exchange knowledge related to new approaches for end-to-end supply chain services process integration.	Not applicable	This is particular to the SC context and hence is not retained.

APPENDIX 4. Measures for Knowledge Exploitation

Reference	Original Item	Adapted Item	Reason for Adaptation or Deletion
Malhotra et al. (2007)	Extent to which you exchange details of upcoming product or service-related changes with partner company	Extent to which we obtain knowledge of upcoming product/service related changes from other internal units.	Adapted slightly to stress partners internal to the value chain.
	Extent to which you exchange future plans such as promotion and marketing plans, long-term production plans, capital investments, and capacity utilization with partner company.	Extent to which we obtain knowledge from each other of future plans such as promotion and marketing plans, capacity utilization.	I dropped some of the terms, such as capital investments, long-term plans, as they are not relevant to our context.
	Extent to which you exchange information related to market demand trends and forecasts with partner company.	Extent to which we obtain details of demand trends and forecasts from each other.	Slightly adapted to stress partners internal to the value chain.
	Extent to which you exchange information on demand shifts and changes in customer preferences with partner company.	Extent to which we obtain details of demand shifts and changes in customer preferences from each other.	Slightly adapted to stress partners internal to the value chain.
	Extent to which we obtain process knowledge from each other to support changes in product features or volumes.	Retained as is	
	Extent to which we obtain knowledge that helps us analyze and redesign processes to improve the performance of the process as a whole	Extent to which we obtain knowledge from internal units that helps us analyze and redesign processes linked to other internal units to improve the performance of	Adapted to stress the knowledge exploitation from internal functions (units).

Reference	Original Item	Adapted Item	Reason for Adaptation or Deletion
		the process as a whole	
	Extent to which you exchange information related to changes in supply chain structure, such as addition or dropping of partner companies, merger, and alliances, with partner company.	Not applicable	This item is related to supply chain context and is not applicable to knowledge exploitation from internal units.
	Extent to which you exchange information related to changes in product features or volumes with partner company.	Extent to which we obtain knowledge from each other about changes in product features or volumes.	Slightly changed to stress partners internal to the value chain.
Im and Rai (2008) Composite Reliability = 0.97	Our companies exchange knowledge related to refining the existing supply chain services process.	Extent to which we leverage existing knowledge from each other to improve products.	The original item is specific to the SC context and asks about refining SC processes. I adapted this to refer to product of the unit as that is more appropriate to our context.
	Our companies exchange knowledge related to improving compliance with short-term goals.	Not applicable	Short-term goals are specific to the original item's context and not relevant for our context. Hence, this item is not retained.
	Our companies exchange knowledge to refine existing measures for assessing short-term performance goals.	Not applicable	Short-term performance is particular to original item's context and not relevant for our context. Hence this item is not retained
	Our companies exchange knowledge for low-risk, short-term improvements.	Not applicable	Low risk, short-term improvement is particular to original item's context and not relevant for our

Reference	Original Item	Adapted Item	Reason for Adaptation or Deletion
			context. Hence this item is not retained
	Our companies exchange knowledge related to refining a few selected parts of the supply chain services process.	Not applicable	This is particular to the SC context and hence is not retained.

APPENDIX 5. Measures for Internal Process Coupling

Reference	Original Item	Adapted Item	Reason for Adaptation or Deletion
Saraf et al. (2007) Composite Reliability = 0.865	The business procedures and routines of our business unit are highly coupled with the ones of our customers.	The business procedures and routines of our unit are highly coordinated with each other.	Changed the context from external customers to internal units
	To operate efficiently, we rely on procedures and routines of our customers.	To operate efficiently, the procedures and routines rely heavily on each other.	Changed the context from external customers to internal units
	Our way of doing business is closely linked with our customers'.	Our way of doing business is closely linked with each other.	Changed the context from external customers to internal units
	Some of our operations are closely connected with the ones of our customers.	Most of our operations are closely connected with each other.	Changed the context from external customers to internal units
	To facilitate operations, our BU's business procedures and routines are linked with the ones of our customers.	Our business procedures and routines are linked with the each other.	Changed the context from external customers to internal units
Rai et al. (2006)	Production and delivery schedules are shared across the supply chain	Production and delivery schedules are shared among processes.	Changed the item context from supply chain to internal units

APPENDIX 6. Measures for External Process Coupling

Reference	Original Item	Adapted Item	Reason for Adaptation or Deletion
Saraf et al. (2007) Composite Reliability = 0.865	The business procedures and routines of our business unit are highly coupled with the ones of our customers.	The business procedures and routines of our unit are highly coordinated with procedures of our external partners	Changed the context from external customers to external partners.
	To operate efficiently, we rely on procedures and routines of our customers.	To operate efficiently, we rely on procedures and routines of our external partners.	Changed the context from external customers to external partners.
	Our way of doing business is closely linked with our customers'.	Our way of doing business is closely linked with that of our external partners.	Changed the context from external customers to external partners.
	Some of our operations are closely connected with the ones of our customers.	Most of our operations are closely connected with the ones of our external partners.	Changed the context from external customers to external partners.
	To facilitate operations, our BU's business procedures and routines are linked with the ones of our customers.	To facilitate operations, our business procedures and routines are linked with the ones of our external partners.	Changed the context from external customers to external partners.
Rai et al. (2006)	We collaborate with our external partners to arrive at demand forecasts	Retained as is	
	Our downstream partners share their actual sales data with us	Retained as is	
	Production and delivery schedules are shared across the supply chain	Retained as is	

APPENDIX 7. Measures for Sensing Capability

Reference	Original Item	Adapted Item	Reason for Adaptation or Deletion
Tallon (2008) Composite Reliability = 0.865	Respond to changes in aggregate consumer demand.	Detect changes in aggregate consumer demand	Changed focus from responding to sensing
	Customize a product or service to suit an individual customer.	Detect the need for customizing products to suit individual customers.	Changed focus from responding to sensing
	React to new product or service launches by competitors.	Detect new product or service launches by competitors	Changed focus from responding to sensing
	Introduce new pricing schedules in response to changes in competitors' prices.	Detect the need to change pricing schedules.	Changed focus from responding to sensing. Also removed the "in response to changes in competitors' prices" part to keep it completely related to sensing.
	Expand into new regional or international markets.	Detect the opportunities (expansion, partnering) in regional and international markets.	Changed focus from responding to sensing
	Change (i.e., expand or reduce) the variety of products / services available for sale.	Detect the need for changing the variety of products/ services available for sale	Changed focus from responding to sensing

Reference	Original Item	Adapted Item	Reason for Adaptation or Deletion
	Adopt new technologies to produce better, faster and cheaper products and services.	Detect the need to adopt new technologies to produce better, faster and cheaper products and services.	Changed focus from responding to sensing
	Switch suppliers to avail of lower costs, better quality or improved delivery times.	Detect the need/opportunity to switch suppliers to avail of lower costs, better quality or improved delivery times.	Changed focus from responding to sensing
Raschke (2010) Cronbach Alpha = 0.94	We can successfully and quickly change functionality of our processes	Detect the need to change functionality of business process.	Changed focus from responding to sensing.
	We can quickly add functionality to our existing range of order fulfillment process.	Not applicable	This is specific to order fulfillment
	We can easily and quickly add or change our order fulfillment process to meet our trading partners' needs	Not applicable	This is specific to order fulfillment

APPENDIX 8. Measures for Responding Capability

Reference	Original Item	Adapted Item	Reason for Adaptation or Deletion
Tallon (2008) Composite Reliability = 0.865	Respond to changes in aggregate consumer demand.	Respond to changes in aggregate consumer demand	
	Customize a product or service to suit an individual customer.	Customize products or services to suit individual customers	
	React to new product or service launches by competitors.	React to new product/service launches by competitors	
	Introduce new pricing schedules in response to changes in competitors' prices.	Introduce new pricing schedules in response to changes in competitors' prices.	
	Expand into new regional or international markets.	Expand into new regional and international markets	
	Change (i.e., expand or reduce) the variety of products / services available for sale.	Change (i.e. expand or reduce) the variety of products / services available for sale.	
	Adopt new technologies to produce better, faster and cheaper products and services.	Adopt new technologies to produce better, faster and cheaper products and services	
	Switch suppliers to avail of lower costs, better quality or improved delivery times.	Switch suppliers to avail of lower costs, better quality or improved delivery times.	
Raschke (2010) Cronbach	We can successfully and quickly change functionality of our order fulfillment process	We can successfully and quickly change functionality of our business process	

Reference	Original Item	Adapted Item	Reason for Adaptation or Deletion
Alpha = 0.94	We can quickly add functionality to our existing range of order fulfillment process.	Not applicable	
	We can easily and quickly add or change our order fulfillment process to meet our trading partners' needs	Not applicable	

APPENDIX 9: Complete Questionnaire

Internal Electronic Integration:

Indicate the extent to which the following statements apply regarding the electronic integration of the manufacturing, operations, procurement, inventory, and order fulfillment IT applications of your business unit.

	Not at all						To a great extent
Definition of key data elements (e.g. customer, order, part number) are common across IT applications		1	2	3	4	5	
Same data (e.g. order status) are stored consistently across IT applications		1	2	3	4	5	
We can easily share our data with each other.		1	2	3	4	5	
We have successfully integrated most of our IT applications.		1	2	3	4	5	
Most of our IT applications work seamlessly across units.		1	2	3	4	5	
Order changes are automatically reflected in all IT applications.		1	2	3	4	5	
Our applications easily transmit, integrate, and process data among each other.		1	2	3	4	5	

Knowledge Exploitation:

Indicate the extent to which the manufacturing, operations, procurement, inventory, and order fulfillment functions of your business unit engage in the following activities with each other.

	Not at all						To a great extent
Leverage existing knowledge from each other to improve products.		1	2	3	4	5	
Obtain knowledge from each other about changes in product features or volumes.		1	2	3	4	5	
Obtain process knowledge from each other to support changes in product features or volumes.		1	2	3	4	5	
Obtain knowledge from each other of future plans such as promotion and marketing plans, capacity utilization.		1	2	3	4	5	
Obtain details of demand trends and forecasts from each other.		1	2	3	4	5	
Obtain details of demand shifts and changes in customer preferences from each other.		1	2	3	4	5	

Internal Process Coupling:

Indicate the extent to which the following statements apply regarding the coordination of the manufacturing, order fulfillment, procurement, operations and inventory processes of your business unit with each other.

	Not at all						To a great extent
The business procedures and routines are highly coordinated with each other.		1	2	3	4	5	
To operate efficiently, the procedures and routines rely heavily on each other.		1	2	3	4	5	
Our way of doing business is closely linked with each other.		1	2	3	4	5	
Most of our operations are closely connected with each other		1	2	3	4	5	
Our business procedures and routines are linked with each other.		1	2	3	4	5	
Production and delivery schedules are shared among processes.		1	2	3	4	5	

External Electronic Integration:

Indicate the extent to which the following statements apply regarding the integration of your IT applications with the IT applications of your most important ***external partners*** *outside the organization (i.e. your unit's closest long-term suppliers and customers).*

	Not at all						To a great extent
Definition of key data elements (e.g. customer, order, part number) are common among our applications and the applications of our external partners.		1	2	3	4	5	
Same data (e.g. order status) stored in different databases are consistent across our applications and those of our external partners.		1	2	3	4	5	
Data are entered only once to be retrieved by most applications of our external partners.		1	2	3	4	5	
We can easily share our data with our external partners.		1	2	3	4	5	
We have successfully integrated most of our applications with the applications of our external partners.		1	2	3	4	5	
Our internal applications (such as our enterprise resource planning application) communicate in real time with the applications of our external partners.		1	2	3	4	5	
Most of our applications work seamlessly with the applications of our external partners.		1	2	3	4	5	
Our systems can easily transmit, integrate, and process data from our external partners.		1	2	3	4	5	

Knowledge Exploration:

Indicate the extent to which your business unit engages in the following activities with your most important ***external partners*** *outside the organization (i.e. your unit's closest long-term suppliers and customers).*

	Not at all						To a great extent
Extent to which we obtain new knowledge about building new products from our external partners.		1	2	3	4	5	
Extent to which we obtain details of upcoming product related changes from our external partners.		1	2	3	4	5	
Extent to which we obtain details of changes in product features or volumes from our external partners.		1	2	3	4	5	
Extent to which we obtain knowledge about new business opportunities from our external partners.		1	2	3	4	5	
Extent to which we obtain knowledge of future plans such as promotion and marketing plans, capacity utilization from our external partners.		1	2	3	4	5	
Extent to which we obtain knowledge of demand shifts and changes in customer preferences from our external partners.		1	2	3	4	5	
Extent to which we obtain knowledge related to demand trends and forecasts from our external partners.		1	2	3	4	5	
Extent to which we obtain knowledge from external partners that helps us better understand the capabilities and intentions of competitors our external partners.		1	2	3	4	5	

External Process Coupling:

*Indicate the extent to which the following statements apply regarding the coordination of your unit's business processes with process activities of your most important **external partners** outside the organization (i.e. your unit's closest long-term suppliers and customers).*

	Not at all						To a great extent
The business procedures and routines of our unit are highly coordinated with procedures of our external partners.		1	2	3	4	5	
To operate efficiently, we rely on procedures and routines of our external partners.		1	2	3	4	5	
Our way of doing business is closely linked with that of our external partners.		1	2	3	4	5	
Most of our operations are closely connected with the operations of our external partners.		1	2	3	4	5	
To facilitate operations, our business procedures and routines are linked with those of our external partners.		1	2	3	4	5	
To arrive at demand forecasts, we collaborate with our external partners.		1	2	3	4	5	

Sensing Capability:

To what extent can your unit easily and quickly ...

	Extremely difficult				Extremely easy
Detect changes in aggregate consumer demand.	1	2	3	4	5
Detect the need for customizing products to suit individual customers.	1	2	3	4	5
Detect new product or service launches by competitors.	1	2	3	4	5
Detect the need to change pricing schedules.	1	2	3	4	5
Detect the opportunities (expansion, partnering) in regional and international markets.	1	2	3	4	5
Detect the need for changing the variety of products/ services available for sale.	1	2	3	4	5
Detect the need to adopt new technologies to produce better, faster and cheaper products and services.	1	2	3	4	5
Detect the need/opportunity to switch suppliers to avail of lower costs, better quality or improved delivery times.	1	2	3	4	5
Detect the need to change functionality of business process.	1	2	3	4	5

Responding Capability: *To what extent can your business unit easily and quickly perform the following business actions:*					
	Extremely difficult				Extremely easy
Respond to changes in aggregate consumer demand.	1	2	3	4	5
Customize products or services to suit individual customers.	1	2	3	4	5
React to new product/service launches by competitors.	1	2	3	4	5
Introduce new pricing schedules in response to changes in competitors' prices.	1	2	3	4	5
Expand into new regional and international markets.	1	2	3	4	5
Change (i.e. expand or reduce) the variety of products / services available for sale.	1	2	3	4	5
Adopt new technologies to produce better, faster and cheaper products and services	1	2	3	4	5
Switch suppliers to avail of lower costs, better quality or improved delivery times.	1	2	3	4	5
Successfully and quickly change functionality of business process.	1	2	3	4	5

Market Orientation and Business unit Size: *Please indicate the extent to which you agree with the following statements:*	
Business strategies are driven by the goal of increasing customer value.	1 2 3 4 5
We emphasize "putting customers first" throughout our business unit.	1 2 3 4 5
Our philosophy of doing business is driven by the need of putting customers first.	1 2 3 4 5
Customer preferences change rapidly for our products.	1 2 3 4 5
There is intense competition for market share in our product market.	1 2 3 4 5
Forecasting demand for our products is very difficult.	1 2 3 4 5
Technological innovations have brought many new product ideas to our product market in the recent past.	1 2 3 4 5
Indicate the annual revenue (in millions of US dollars) of your business unit.	

Appendix 10-A (Results of First Round Card-Sort)

	IEI	EEI	KER	KET	IPC	EPC	SEN	Resp	Avg Agree (for item)
Internal Electronic Integration (13 items)									
Definition of key data elements (e.g. customer, order, part number) are common across IT applications	9				1				0.90
Same data (e.g. order status) are stored consistently across IT applications	9				1				0.90
Data are entered only once to be retrieved by most applications.	8				2				0.8
We can easily share our data with each other	9				1				0.9
We have successfully integrated most of our IT applications.	10								1
Most of our applications work seamlessly across units.	9				1				0.9
Order changes are automatically reflected in all IT applications.	8				1		1		0.8
Our applications easily transmit, integrate, and process data among each other.	10								1
Our transactional applications communicate seamlessly with other units (procurement, manufacturing, distribution)	9				1				0.9
Our planning applications communicate seamlessly with other units (e.g. demand planning, transactional planning, manufacturing planning)	9				1				0.9
All our internal units from raw material management through production, shipping, and sales are connected and integrated in real-time.	6				4				0.6
Our logistics-related operating data are searchable in real-time.	7			2	1				0.7
Our inventory data are searchable in real-time.	8			2					0.8
External Electronic Integration (10 items)									
Definition of key data elements (e.g. customer, order, part number) are common among our applications and the applications of our external partner.		9				1			0.9
Same data (e.g. order status) stored in different databases are consistent across our applications and those of external partners.		9				1			0.9
Data are entered only once to be retrieved by most applications		10							1
We can easily share our data with our external partners.		10							1
We have successfully integrated most of our applications with the applications of our external partners.		10							1
Most of our applications work seamlessly with the applications of our external partners.		9				1			0.9

	IEI	EEI	KER	KET	IPC	EPC	SEN	Resp	Avg Agree (for item)
Order changes are automatically reflected in applications of our external partners.		7				3			0.7
Our systems can easily transmit, integrate, and process data from external partners.		9				1			0.9
Our internal applications (such as our enterprise resource planning application) communicate in real time with the applications of external partners.		9				1			0.9
Customer and supplier relationship applications communicate in real time with internal applications of our unit.	1	8			1				0.8
Knowledge Exploration (9 items)									
Extent to which we obtain new knowledge from external partners to help in building new products.			10						1
Extent to which we obtain details of upcoming product related changes from external partners			9				1		0.9
Extent to which we obtain details of changes in product features or volumes from external partners			8			1	1		0.8
Extent to which we obtain knowledge about new business opportunities from external partners.			10						1
Extent to which we obtain knowledge of future plans such as promotion and marketing plans, capacity utilization from external partners			10						1
Extent to which we obtain knowledge of demand shifts and changes in customer preferences from external partners			10						1
Extent to which we obtain knowledge related to demand trends and forecasts from external partners			9				1		0.9
Extent to which we obtain knowledge from external partners that helps us better understand the capabilities and intentions of competitors			9				1		0.9
Extent to which we obtain knowledge from external partners that helps us analyze and redesign processes linked to channel partners to improve the performance of the channel as a whole			9				1		0.9
Knowledge Exploitation (8 items)									
Extent to which we leverage existing knowledge from each other to improve products.				9		1			0.9
Extent to which we obtain knowledge of upcoming product/service related changes from other internal units.				9		1			0.9
Extent to which we obtain knowledge from each other about changes in product features or volumes.				9		1			0.9
Extent to which we obtain process knowledge from each other to support changes in product			1	9					0.9

	IEI	EEI	KER	KET	IPC	EPC	SEN	Resp	Avg Agree (for item)
features or volumes.									
Extent to which we obtain knowledge from each other of future plans such as promotion and marketing plans, capacity utilization.				10					1
Extent to which we obtain details of demand trends and forecasts from each other.				9	1				0.9
Extent to which we obtain details of demand shifts and changes in customer preferences from each other.				9	1				0.9
Extent to which we obtain knowledge from internal units that helps us analyze and redesign processes linked to other internal units to improve the performance of the process as a whole				10					1
Internal Process Coupling (6 items)									
The business procedures and routines of our unit are highly coordinated with each other.					9	1			0.9
To operate efficiently, the procedures and routines rely heavily on each other.				1	9				0.9
Our way of doing business is closely linked with each other.					10				1
Most of our operations are closely connected with each other.	1				9				0.9
Our business procedures and routines are linked with the each other.					10				1
Production and delivery schedules are shared among processes.	2				8				0.8
External Process Coupling (8 items)									
The business procedures and routines of our unit are highly coordinated with procedures of our external partners						10			1
To operate efficiently, we rely on procedures and routines of our external partners.						10			1
Our way of doing business is closely linked with that of our external partners.						10			1
Most of our operations are closely connected with the ones of our external partners.		2				8			0.8
To facilitate operations, our business procedures and routines are linked with the ones of our external partners.						9			0.9
We collaborate with our external partners to arrive at demand forecasts			2			7	1		0.7
Our downstream partners share their actual sales data with us	1	4	2			3			0.3
Production and delivery schedules are shared across the supply chain with external partners.		2	2			6			0.6
Sensing (9 items)									
Detect changes in aggregate consumer demand							10		1
Detect the need for customizing products to suit							10		1

	IEI	EEI	KER	KET	IPC	EPC	SEN	Resp	Avg Agree (for item)
individual customers.									
Detect new product or service launches by competitors							10		1
Detect the need to change pricing schedules.							10		1
Detect the opportunities (expansion, partnering) in regional and international markets.							10		1
Detect the need for changing the variety of products/ services available for sale							10		1
Detect the need to adopt new technologies to produce better, faster and cheaper products and services.							10		1
Detect the need/opportunity to switch suppliers to avail of lower costs, better quality or improved delivery times.							10		1
Detect the need to change functionality of business process.							10		1
Responding (9 items)									
Respond to changes in aggregate consumer demand								10	1
Customize products and services to suit individual customers.								10	1
React to new product or service launches by competitors								10	1
Introduce new pricing schedules in response to changes in competitors' prices.								10	1
Expand into new regional and international markets								10	1
Change (i.e. expand or reduce) the variety of products / services available for sale.								10	1
Adopt new technologies to produce better, faster and cheaper products and services								10	1
Switch suppliers to avail of lower costs, better quality or improved delivery times.								10	1
We can successfully and quickly change functionality of our business process					1			9	0.9
Total Card per Construct (category)	116	98	91	79	73	76	97	89	719
No. of different cards per construct	5	8	7	5	18	13	7	0	63
Total Hits	111	90	84	74	55	63	90	89	656
Ratio of Total Hits/Total card	0.96	0.92	0.92	0.94	0.75	0.83	0.93	1.00	0.91
Average agreement (category)	0.85	0.9	0.93	0.92	0.92	0.78	1	0.98	0.91
No. of participants	10								
No. of items per construct	13	10	9	8	6	8	9	9	

Appendix 10-B (Results of Second Round Card Sort)

	IEI	EEI	KER	KET	IPC	EPC	SEN	RES	Avg Agree (for item)
Internal Electronic Integration (12 items)									
Definition of key data elements (e.g. customer, order, part number) are common across IT applications	8				1				0.89
Same data (e.g. order status) are stored consistently across IT applications	8				1				0.89
Data are entered only once to be retrieved by most applications.	7	2							0.78
We can easily share our data with each other	9								1
We have successfully integrated most of our IT applications.	9								1
Most of our applications work seamlessly across units.	9								1
Order changes are automatically reflected in all IT applications.	8				1				0.89
Our applications easily transmit, integrate, and process data among each other.	9								1
Our transactional applications communicate seamlessly with other units (procurement, manufacturing, distribution)	7				2				0.78
Our planning applications communicate seamlessly with other units (e.g. demand planning, transactional planning, manufacturing planning)	7				2				0.78
Our logistics-related operating data are searchable in real-time.	5	1		2		1			0.56
Our inventory data are searchable in real-time.	5	1	1	2					0.56
External Electronic Integration (10 items)									
Definition of key data elements (e.g. customer, order, part number) are common among our applications and the applications of our external partners.		8				1			0.89
Same data (e.g. order status) stored in different databases are consistent across our applications and those of external partners.		8				1			0.89

	IEI	EEI	KER	KET	IPC	EPC	SEN	RES	Avg Agree (for item)
Data are entered only once to be retrieved by most applications		9							1
We can easily share our data with our external partners.		8				1			0.89
We have successfully integrated most of our applications with the applications of our external partners.		8				1			0.89
Most of our applications work seamlessly with the applications of our external partners.		8				1			0.89
Data related to order changes are automatically reflected in applications of our external partners.		6				3			0.67
Our systems can easily transmit, integrate, and process data from external partners.		8				1			0.89
Our internal applications (such as our enterprise resource planning application) communicate in real time with the applications of external partners.		9							1
Customer and supplier relationship applications communicate in real time with internal applications of our unit.	4	5							0.56
Knowledge Exploration (9 items)									
Extent to which we obtain new knowledge about building new products from external partners.			9						1
Extent to which we obtain details of upcoming product related changes from external partners			8				1		0.89
Extent to which we obtain details of changes in product features or volumes from external partners			8				1		0.89
Extent to which we obtain knowledge about new business opportunities from external partners.			9						1
Extent to which we obtain knowledge of future plans such as promotion and marketing plans, capacity utilization from external partners			8				1		0.89
Extent to which we obtain knowledge of demand shifts and changes in customer preferences from external partners			8					1	0.89
Extent to which we obtain knowledge related to demand trends and forecasts from external partners			8					1	0.89
Extent to which we obtain knowledge from external partners that helps us better understand the capabilities and intentions of competitors			8					1	0.89

	IEI	EEI	KER	KET	IPC	EPC	SEN	RES	Avg Agree (for item)
Extent to which we obtain knowledge from external partners that helps us analyze and redesign processes linked to channel partners to improve the performance of the channel as a whole			5			2		2	0.56
Knowledge Exploitation (8 items)									
Extent to which we leverage existing knowledge from each other to improve products.			1	8					0.89
Extent to which we obtain knowledge of upcoming product/service related changes from other internal units.			2	6	1				0.75
Extent to which we obtain knowledge from each other about changes in product features or volumes.				8	1				0.89
Extent to which we obtain process knowledge from each other to support changes in product features or volumes.				9					1
Extent to which we obtain knowledge from each other of future plans such as promotion and marketing plans, capacity utilization.				9					1
Extent to which we obtain details of demand trends and forecasts from each other.				8				1	0.89
Extent to which we obtain details of demand shifts and changes in customer preferences from each other.				8				1	0.89
Extent to which we obtain knowledge from internal units that helps us analyze and redesign processes linked to other internal units to improve the performance of the process as a whole				6	2			1	0.67
Internal Process Coupling (6 items)									
The business procedures and routines of our unit are highly coordinated with each other.					9				1
To operate efficiently, the procedures and routines rely heavily on each other.				1	8				0.89
Our way of doing business is closely linked with each other.					9				1
Most of our operations are closely connected with each other.					9				1
Our business procedures and routines are linked with the each other.					9				1

	IEI	EEI	KER	KET	IPC	EPC	SEN	RES	Avg Agree (for item)
Production and delivery schedules are shared among processes.					9				1
External Process Coupling (8 items)									
The business procedures and routines of our unit are highly coordinated with procedures of our external partners		1				8			0.89
To operate efficiently, we rely on procedures and routines of our external partners.		1				8			0.89
Our way of doing business is closely linked with that of our external partners.		1				8			0.89
Most of our operations are closely connected with the ones of our external partners.		1				8			0.89
To facilitate operations, our business procedures and routines are linked with the ones of our external partners.		1				8			0.89
To arrive at demand forecasts, we collaborate with our external partners.			1			8			0.89
Our downstream partners share their actual sales data with us		3	2			3	1		0.34
Production and delivery schedules are shared across the supply chain with external partners.		1	1			5		2	0.56
Sensing (9 items)									
Detect changes in aggregate consumer demand							9		1
Detect the need for customizing products to suit individual customers.							9		1
Detect new product or service launches by competitors							9		1
Detect the need to change pricing schedules.							9		1
Detect the opportunities (expansion, partnering) in regional and international markets.							9		1
Detect the need for changing the variety of products/ services available for sale							9		1

	IEI	EEI	KER	KET	IPC	EPC	SEN	RES	Avg Agree (for item)
Detect the need to adopt new technologies to produce better, faster and cheaper products and services.							8	1	0.89
Detect the need/opportunity to switch suppliers to avail of lower costs, better quality or improved delivery times.							9		1
Detect the need to change functionality of business process.							9		1
Responding (9 items)									
Respond to changes in aggregate consumer demand								9	1
Customize products and services to suit individual customers.								9	1
React to new product or service launches by competitors						1		8	0.89
Introduce new pricing schedules in response to changes in competitors' prices.								9	1
Expand into new regional and international markets								9	1
Change (i.e. expand or reduce) the variety of products / services available for sale.								9	1
Adopt new technologies to produce better, faster and cheaper products and services								9	1
Switch suppliers to avail of lower costs, better quality or improved delivery times.								9	1
We can successfully and quickly change functionality of our business process								9	1
Total Card per Construct (category)	95	90	80	67	64	68	84	91	639
No. of different cards per construct	4	13	9	5	11	13	4	11	70
Total Hits	91	77	71	62	53	55	80	80	569
Ratio of Total Hits/Total card	0.96	0.86	0.89	0.93	0.83	0.81	0.95	0.88	0.89
Average agreement (category)	0.84	0.86	0.88	0.87	0.98	0.76	0.98	0.98	0.89
No. of participants	9								
No. of items per construct	12	10	9	8	6	8	9	9	

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