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Relating agility and electronic integration: The role of knowledge and process coordination mechanisms

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ABSTRACT

Current competitive environments necessitate that firms pursue electronic integration in parallel to agility. However, most research to date has examined integration and agility relatively independently and has overlooked the relationship between them. Using coordination theory, this paper suggests that integration enables the two capabilities of agility (i.e., sensing and responding). Results from a study of 303 business unit operations of manufacturing organizations show that integration within business units and with outside partners is positively associated with process coupling of the value chain, both internally and externally. Further, both types of integration are positively associated with knowledge flow within and outside the business unit. In turn, both lead to higher capability to sense change in the business environment and respond to it with agility. This research helps us understand the integration-agility relation better by investigating the role of the knowledge and process capabilities.

Introduction

The contemporary business environment is becoming increasingly competitive as businesses face intense globalization and time-to-market pressures (Lu and Ramamurthy, 2011). To be successful in such competitive environments, businesses strive to attain *agility* (i.e., the capability of firms to sense and respond to opportunities and threats with speed and innovativeness, Lu and Ramamurthy, 2011) to capitalize on emerging business opportunities and survive impending threats (Chakravarty et al., 2013; Overby et al., 2006). In parallel, businesses also invest in *electronic integration* to maintain constant communications with customers and partners, and attain unfettered access to information across values chains (Barki and Pinsonneault, 2005). Electronic integration (defined as the extent to which IS applications of a unit work as a functional whole, internally and in conjunction with the IS applications of external partners outside of the business unit) has become an important organizational goal and companies spend substantial sums of money to achieve it (Rai et al., 2006; Lu and Ramamurthy, 2011). Companies have focused on these two goals in parallel without giving much attention to how agility is affected as organizations become more electronically integrated.

IS research on integration and agility has followed a trajectory similar to that of practice. The two research streams have developed independently without much understanding of how integration relates to agility. Most agility literature has focused on studying the effects of broad IT constructs on agility, such as the alignment between business and IT strategy (Tallon and Pinsonneault, 2011), technical and managerial IT skills (Lu and Ramamurthy, 2011), IT competencies (Chakravarty et al., 2013), IT personnel capabilities

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(Fink and Neumann, 2009) and inter-functional and channel coordination (Roberts and Grover, 2012). Some IS literature has also placed significant importance on IT agility, the capability to respond operationally and strategically to environmental changes through IT (Fink and Neumann, 2009; Lowry and Wilson, 2016). Although IT agility and other similar high-level IT capabilities can play an important role in achieving business unit agility, we believe it is important to first establish how individual capabilities such as integration relate to business unit agility's sensing and responding components. Research on integration has also largely overlooked agility as a potential outcome. The literature has focused primarily on efficiency-oriented constructs, such as number of policies sold (Venkatraman and Zaheer, 1990), operating costs (Srinivasan et al., 1994), gains in sales volume (Mukhopadhyay and Kekre, 2002), and cost savings (Xue et al., 2013). We have yet to empirically examine the relationship between the two constructs using a robust theoretical approach to establish the underlying relation between integration and agility (Koufteros et al., 2005). Not knowing how integration relates to agility has important consequences for research and practice. Practitioners could find themselves in a quandary about whether to pursue integration or not, wary that it may cripple their capacity to sense and respond to change. Thus, they may choose to not integrate fully, resulting in not attaining all the potential benefits of the enterprise systems. The situation is even more perplexing for research. Without a solid understanding of the integration-agility relation, our ability to cumulate empirical evidence over time and across studies will be restrained (Parsons and Wand, 2008) which, in turn, will hinder effective dialogue among researchers. It also leads us to poorly specified research models that give us results that are of no use (Parsons and Wand, 2008).

This paper fills the gap in the literature regarding the integration-agility relation. Our work builds on the work of Roberts and Grover (2012). Roberts and Grover (2012) examined the relationship between coordination and integration and customer responding agility and found that external integration does not create synergies that enhance customer responding agility. The present paper extends this line of research by investigating the relationship of internal and external integration with both, the focal business unit's ability to detect as well as respond to environmental changes. Moreover, the current paper also addresses the question of *how* electronic integration relates to sensing and responding by examining the mediating role of process coupling and knowledge flow. We suggest that using a coordination theory perspective (March and Simon, 1958) can shed light on the integration-agility relation. Coordination theory posits that standardization of IS applications helps coordinate process activities (process coupling) and enables intensified exchange of information and knowledge about impending changes in the environment (knowledge exploitation and knowledge exploration) (Gosain et al., 2005). These knowledge and process capabilities are critical as they enable translation of IT capabilities into sensing and responding capabilities (Im and Rai, 2008; Sambamurthy et al., 2003). Thus, we use coordination theory to investigate the integration-agility relation by unpacking the role of knowledge and process related capabilities.

This paper also contributes towards the development of the agility construct. Quite a bit of work has been done on the agility concept, but not much has been done to understand its individual components and how they relate to different organizational conditions (Overby et al., 2006). Previous studies have used the responding construct as a proxy for the entire agility construct (e.g. Silveira and Cagliano, 2006; Swafford et al., 2008) and omit the sensing element. Distinguishing the two different capabilities of agility (sensing and responding) and investigating the impact of integration on the individual capabilities is important as the capabilities do not necessarily covary (Overby et al., 2006) and it is possible for a firm to have varying degrees of sensing and responding capabilities (Nazir and Pinsonneault, 2012; Overby et al., 2006)[1]. Hence, this paper offers a contribution 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 question: *What is the relationship between electronic integration and the sensing and responding capabilities of a business unit?*

The unit of analysis is the business unit. We use the concept of value chain to focus on the key functions of a business unit (see Fig. 1 below). A value chain comprises the key business functions of a business unit 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; Raschke, 2010). These are the primary functions of the value chain and are internal to the business unit. External to the business unit are the connections to entities external to the focal business unit, such as suppliers and customers (Frohlich and Westbrook, 2001; Rosenzweig et al., 2003; Vickery et al., 1999), collectively referred to as external partners of the business unit in this paper (see Fig. 1).

The rest of this article is structured as follows. The subsequent section introduces the theoretical underpinnings of this research followed by the hypotheses from the research model. We then describe the research methodology and present the findings before discussing the research implications and the conclusions drawn from this study.

Theoretical background

Information systems literature has primarily looked at two types of integration, internal and external. Some studies investigated the effect of integration with other internal units inside the organization (e.g., Antonio et al., 2009; Booth et al., 2000; Coronado et al., 2002; Dasgupta et al., 1999; Lu and Ramamurthy, 2011; Narasimhan and Das, 1999; Putnik and Sluga, 2007) while other studies investigated the effects of integration with outside partners (e.g., 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). Electronic integration,

[1] In this paper, 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. While this paper 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 units are beyond the scope of this paper.

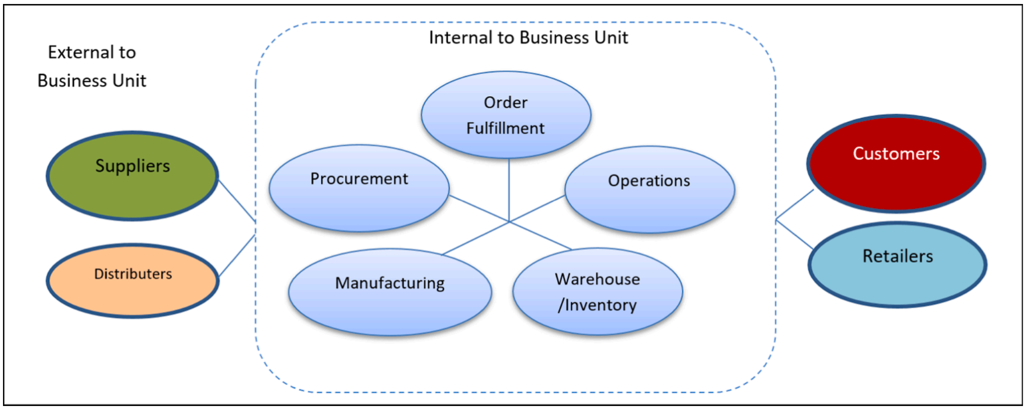

Fig. 1. Internal functions and external partners of the business unit.

often referred to as IS integration (e.g. Saeed et al., 2005; Saraf et al., 2007), is the extent to which IS applications of a unit work as a functional whole, internally and in conjunction with the IS applications of external partners outside of the business unit. It is at the functional level and is conceptually different from process coupling, which is the extent to which process activities of a unit are intermeshed with partners such that they are operationally coordinated. Studies suggest that electronic integration can lead to processes that are coupled (Markus and Tanis, 2000) and can also allow for transfer of knowledge among internal and external partners (Rai and Tang, 2010). Coordination theory helps us establish that process coupling and knowledge transfer serve as coordination mechanisms that allow companies to sense changes in their environment and respond to them in a timely manner.

Coordination theory argues that coordination can be achieved through two mechanisms, *coordination by plan* and *coordination by feedback*[2] (March and Simon, 1958). In coordination by plan, streamlined linkages are created and decided upon up front with utmost detail (March and Simon, 1958). Units use this coordination mechanism for the most routine aspects of tasks because the respective dependencies are more predictable, and hence, can be managed easily in a programmed way (Bailey et al., 2010). In organizational settings, the formalized manner in which standardized communication protocols and inputs and outputs of IS applications have been predefined creates streamlined process linkages among organizational functions (Gosain et al., 2005). This operational coordination of process activities is a manifestation of *process coupling*, internally within organizational units (Antonio et al., 2009) and externally with units outside of business unit boundaries such as with suppliers, partners or customers (Rai et al., 2006; Wang and Wei, 2007). Business units attaining high process coupling are operationally integrated (Robicheaux and Coleman, 1994) which not only enables the automating of routine tasks but also allows joint actions and quicker assistance with exception handling (Saraf et al., 2007). This level of process coupling facilitates smooth information, goods, and financial flow (Rai et al., 2006), which in turn is positively associated with the responding capability of business units.

The second coordination mechanism, coordination by feedback, is related to unanticipated changes in the environment (March and Simon, 1958). When organizational routines change or when tasks have few or no routine aspects, coordination by plan mechanisms are less effective (Bailey et al., 2010). Under such circumstances, organizational units need to communicate extensively to cope with change. In organizational settings, this type of coordination is achieved through exchange of knowledge among organizational units that allows them to stay continually attuned to impending changes in the environment (Gosain et al., 2005). The messages, information, and broadly speaking, knowledge that is exchanged using integrated enterprise systems to cope with changes in the environment are a manifestation of the coordination by feedback enabled by these IT applications. The knowledge transferred between internal functions of the business unit can provide 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). Knowledge gained from external partners of the business unit allows the business unit to collect information related to potential threats and opportunities in the environment and respond to them (Hoyt et al., 2007). The role of integrated applications in enhancing knowledge through internal and external units is well highlighted in research related to the impacts of IS on knowledge management (e.g. Carlile, 2004; Malhotra et al., 2007). Research has conceptualized standard enterprise business interfaces as boundary objects that enable collaborative information and knowledge exchange (Malhotra et al., 2007). This knowledge constitutes not only transactional information, but also collaborative information which is value-added information that goes beyond normal transactional data. This knowledge can be obtained primarily from two sources – existing sources inside the business unit or new

[2] Coordination literature identifies several coordination mechanisms. Van de Ven et al. (1976) classify coordination mechanisms such as impersonal, personal and group modes of coordination. Nassimbeni (1998) suggest coordination by standardization and mutual adjustment. Bensaou and Venkatraman (1996) suggest structural, process and technological mechanisms of coordination. These coordination mechanisms essentially conform to the two main categories of coordination, coordination by plan and coordination by feedback suggested by March and Simon (1958). Focusing on the purely technological mechanisms of coordination, Gosain et al. (2005) suggested that March and Simon's (1958) overarching coordination mechanisms (coordination by plan and coordination by feedback) inform the enterprise setting well. Thus, we chose to incorporate only these coordination mechanisms as these coordination mechanisms relate closely to interdependent process activities.

sources outside the business unit (March, 1991; 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. This is knowledge that is embedded within the different functional areas of a business unit. The key idea in knowledge exploitation is the leveraging of knowledge of different functional units to sense and respond to environmental change. Knowledge exploration is related to securing and developing knowledge from new domains such as external partners and customers. Integrated applications such as ERP and SCM systems play an important role in enhancing organizational knowledge from both existing and new sources, and have the potential to enhance the sensing and responding capabilities of firm units (Devaraj et al., 2007). This knowledge can be about opportunities and threats in the environment that a business unit's partners may be aware of. Essentially, this would constitute knowledge that is relatively new to the focal business unit. The constructs and their definitions used in this study are given in Table 1 below.

To summarize, coordination theory allows us to reason that the integration enabled by enterprise systems facilitates 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 are positively associated with the ability to sense changes in the environment and allow for responsiveness to these changes through speedy communication of knowledge among functions and quick adjustment of processes. We elaborate further on the reasoning regarding these relations and present our conceptual model along with formal hypotheses in the next section.

Research model and hypothesis development

The relation between electronic integration and agility

Electronic integration (EI) facilitates the transfer and sharing of data, information, and most importantly, knowledge (Saraf et al., 2007). Business units that attain integration of their internal units and with their external partners develop the capacity to leverage knowledge about their competitive environment. Essentially, internal electronic integration is positively associated with the ability to gain knowledge from within their internal functional units, which we refer to as knowledge exploitation; external electronic integration is positively associated with the ability to gain knowledge from their external partners which we refer to as knowledge exploration. Leveraging these knowledge exploitation and knowledge exploration capabilities, business units are able to quickly sense changes in their environment and respond to these changes in an agile manner. Moreover, internal and external electronic integration also facilitate coordination and seamless synchronization of process activities (Espinosa et al., 2007). Internal electronic integration is positively related to internal process coupling while external electronic integration is positively related to external process coupling (see Fig. 2).

Leveraging the internal and external process coupling capabilities, business units are able to respond to change in their environment with agility (Overby et al., 2006). We elaborate further on the individual hypotheses in the following sections.

Internal electronic integration and knowledge exploitation

Electronic integration of internal value chain applications is positively associated with a unit's ability to exploit current knowledge sources. To achieve electronic integration, business 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). This results in standardization of communication protocols which enables development of shared meanings and emergence of a common language among

Table 1
Constructs and their definitions.

Construct and source	Definition
Internal electronic integration (Rai et al., 2006; Saraf et al., 2007)	The extent to which IS applications of a unit work as a functional whole.
External electronic integration (Rai et al., 2006; Saraf et al., 2007)	The extent to which IS applications of a unit work as a functional whole in conjunction with the IS applications of external partners outside of the business unit.
Internal process coupling (Rai et al., 2006; Saraf et al., 2007)	The extent to which process activities of a unit are intermeshed such that they are operationally coordinated.
External process coupling (Rai et al., 2006; Saraf et al., 2007)	The extent to which process activities of a unit are intermeshed with external partners such that they are operationally coordinated.
Knowledge exploitation (Im and Rai, 2008; Malhotra et al., 2007)	Knowledge exploitation is defined as the extent to which a business unit leverages existing domains of knowledge from inside the unit.
Knowledge exploration (Im and Rai, 2008; Malhotra et al., 2007)	Knowledge exploration is defined as the extent to which a business unit appropriates new domains of knowledge such as from sources outside of the unit.
Sensing (Raschke, 2010; Tallon, 2008)	The ability to detect changes and developments in the environment external to the business unit (such as customer environment, market environment, competitor environment).
Responding (Raschke, 2010; Tallon, 2008)	The ability to respond to changes and developments in the environment external to the business unit (such as customer environment, market environment, and competitor environment)

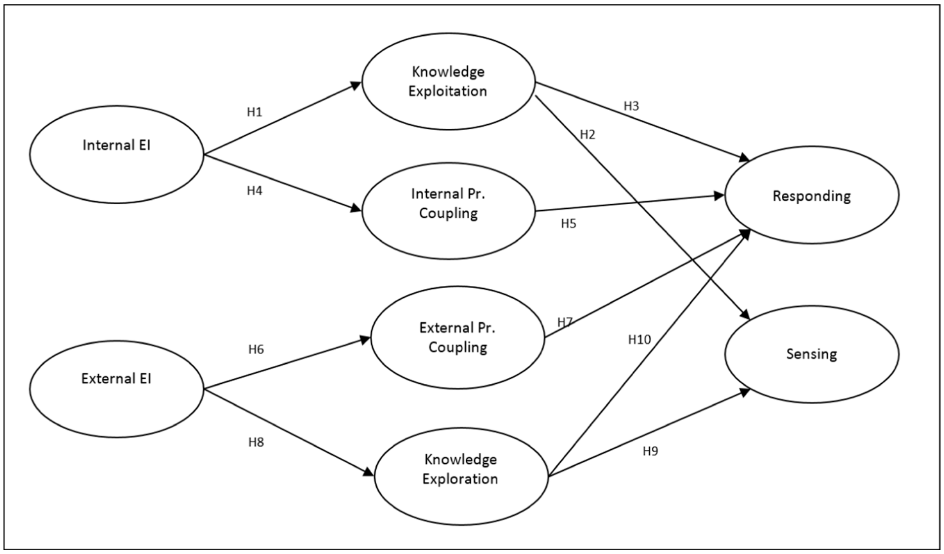

Fig. 2. The relations between EI on sensing and responding capabilities.

internal functional units (Saraf et al., 2007), forming the basis of knowledge transfer among organizational functions (Grant, 1996). By enabling a common language, electronic integration allows for efficiency in knowledge transfer between individual functions by enhancing unit-level capability of acquiring, transforming, mixing, and matching knowledge across value-chain activities (Saraf et al., 2007). Moreover, as electronic integration standardizes organizational data across applications, complex and tacit knowledge related to markets and procedures is converted into simple and explicit knowledge (Nonaka and von Krogh, 2009). This conversion of complex knowledge into explicit knowledge brings together the perspectives of different functional units and expands the scope and depth of existing knowledge (Kessler et al., 2000; Nonaka and von Krogh, 2009). For instance, an ethnographic study showed how a CAD system using standardized forms and reporting formats, enabled engineers in different operational areas to understand the other party's perspective and exploit knowledge from existing knowledge domains, which was not possible before (Carlile, 2004). Coordination theory suggests that integration also results in less information overload, which may help speed up "information metabolism" of organizational units as they will be better able to move it around, digest it and respond to it (Malone et al., 1999). Hence, we propose:

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

Knowledge exploitation and sensing capability

Leveraging existing knowledge from several business unit functions reduces information asymmetry (Gulati et al., 2000) and enables the business unit to sense change in a larger number of environmental variables (Gupta and Govindarajan, 2000; Hansen, 2002). Research on the knowledge-based view of the firm stresses that knowledge sharing among organizational functions facilitates horizontal transfer of knowledge (Tsai, 2001; Piao and Zajac, 2015). The diversity of knowledge that functionally dissimilar units bring to bear on an issue challenges the dominant mindset (Leonard and Sensiper, 1998) and improves the chances that units will be able to sense opportunities that might not be too obvious or that units might even be able to turn impending threats into potential opportunities (Tsai and Ghoshal, 1998). For instance, a clothing manufacturer's business unit might leverage the marketing division's knowledge so that it can analyze sales data to detect changes in 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 capture a larger share of the market by offering discounts on products that are high in demand. Without such heterogeneous insights, business units may choose to maintain the status quo causing them to miss potential opportunities. Hence, we propose:

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

Knowledge exploitation and responding capability

Leveraging knowledge from internal functions enhances the combinative capabilities of a business unit and creates an expanded knowledge base, which enables the business unit to propose radical and complex responses (Grant, 1996). These responses could be in the shape of new products or improvements of existing products or adjustments in processes to respond to changing customer needs (Kogut and Zander, 1992). Moreover, knowledge exploitation enables routines for continuous leveraging of current knowledge repositories (Benner and Tushman, 2003). By bringing together knowledge from internal functions and explicitly embedding it in organizational routines, the business unit enables a collective, accessible memory (data, analysis, relationships among variables) (Nonaka and von Krogh, 2009) which serves the purpose of quickly matching impending problems and opportunities with appropriate responses. For instance, Unilever's Microbiological Design Approval system enables product developers to rapidly gain knowledge from 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). In this example, the design approval system plays the role of a boundary object that allows for detailed knowledge about design flaws to be exchanged by enabling the product developers and product specialists to share knowledge from their respective knowledge domains. 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. Often this long, slow process significantly delayed responsiveness to market changes. Hence, we propose:

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

Internal electronic integration and internal process coupling

Internal electronic integration allows unfettered data access across internal functions (Truman, 2000). This seamless flow of data is characterized by not only syntactic integration of databases but also semantic integration among functions (Yang and Papazoglou, 2000). It has the effect of promoting high level process coupling among participating internal functions (Chen et al., 2009). 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).

Internal electronic integration of applications is achieved through standardized business interfaces (Gosain et al., 2005), leading to standardized routines and operating procedures, which enable operational coordination and promote 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 positively associates to higher process coupling in the firm. Hence, we propose:

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

Internal process coupling and responding capability

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). It streamlines process activities allowing access to customer order, inventory, and planning information throughout the value chain (Lee et al., 2008). 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) and the inventory management unit can update its inventory levels and place orders to suppliers for inventory replenishments. This reduces inefficiencies such as excessive inventory investments, missed production schedules, and poor customer service. (Christopher, 2000). Due to this close coordination of process activities, internal units are able to rapidly and adequately respond to the demands of the other units as well as the environment (Robicheaux and Coleman, 1994; Saraf et al., 2007). 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). Hence, we propose:

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

External integration and external process coupling

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). In order to attain electronic integration, partners in an exchange relation customize their applications and databases to establish specialized communication routines throughout the value chain. This creates seamless coordination of process activities (Malone et al., 1999). Electronic integration has the characteristics of vertical integration (Zaheer and Venkatraman, 1994), where partners in an exchange relationship make investments that enable close process coordination and interdependence between participants. It enables a hybrid governance structure, which improves coordination capabilities (Clemons et al., 1993; Saeed et al., 2005; Wang et al., 2006). When partners in a relationship invest in mutual assets (such as SCM systems), 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 and the resulting coordination promotes greater alignment of process activities, which facilitates increased process coupling between trading partners (Paulraj et al., 2008). Hence, we propose:

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

External process coupling and responding capability

Coordination theory suggests that process coupling streamlines process activities. This allows partners in a relation to focus their attention on production tasks while the coordination tasks are handled by the pre-configured, streamlined process (Malone et al., 1999). The interacting units can continue to be well-coordinated with each other while still maintaining their requisite diversity and independence (Gosain et al., 2005). 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; Orton and Weick, 1990). This coordination of diverse entities allows the combination of a wider range of capabilities that manifest greater responsiveness to the environment (Christopher, 2000).

Having process activities tailored to partner requirements creates specialized routines that instill greater comprehension of the business context (Benner and Tushman, 2003). This allows for rapid screening and development of innovations that can serve as responses to customer needs (Benner and Tushman, 2003). For instance, 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). The close alignment of their process activities improved their overall responsiveness to the environment. Hence, we propose:

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

External electronic integration and 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). The process of creating electronic linkages promotes cooperation and opens up channels for continuous interaction among partners. Electronic integration with external partners manifests the development of trust and a commitment to long-term interactions. Thus, it is more likely that units that have high electronic integration with each other would share new knowledge that each has gathered compared to partners that have low or no integration. External electronic integration, therefore, increases the chances of appropriating new knowledge by expanding the range of knowledge that is accessed through partners (Dyer and Singh, 1998).

Studies suggest that standardized systems can serve as boundary-spanning objects for firms and facilitate knowledge exploration by providing access to resources not found internally (Kane and Alavi, 2008; Malhotra et al., 2007). Standard enterprise business interfaces can enable spanning of syntactic, semantic and pragmatic boundaries (Carlile, 2004). This, in turn, promotes the flow of new knowledge across boundaries (Malhotra et al., 2007). Thus, external integration positively relates to exploration of new knowledge from existing customers and suppliers. For example, it may facilitate feedback from suppliers about initial product designs or allow customers to engage in collaborative design through common systems. Hence, we propose:

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

Knowledge exploration and sensing capability

Although knowledge from internal functions is useful in order to continuously improve products and processes, it provides a convergent perspective on issues (Burt, 1992). We argue that knowledge from external partners is positively associated with 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 (Kane and Alavi, 2008; Powell et al., 1996). It allows a business unit to expand the range of the environment it surveys and become an extended enterprise (Rai et al., 2006), one that is better equipped to sense environmental changes.

Second, 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 can enable long-term rewards and sustained competitive advantage. Through knowledge exploration, business units learn new competencies, which can allow them to devise ways to strategically reorient their activities. In addition, it encourages risk-taking behavior as more of the environmental variables become clear. Knowledge exploration allows a business unit to focus on distance search rather than merely on local search within the organization, thus enabling greater sensing opportunities (Capaldo, 2007; Im and Rai, 2008). Finally, repeated interactions with diverse external partners force the business 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 unit 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 for the focal unit. For instance, IBM created its "Inside IBM" initiative, which allowed it to trigger a diagnostic device at the customer's end to acquire data on system configuration and performance (Massey et al., 2001). Using sophisticated data-mining techniques on the collected data, hardware and software problems that were likely to occur could be predicted before they happened. Following these arguments, we propose:

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

Knowledge exploration and responding capability

Knowledge exploration with external partners allows access to diverse knowledge pools which can result in new ideas for responding to the complex events faced by the business unit (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 needed to obtain the best solution for an impending event (Chi et al., 2007). 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. Responding to changes in the environment often entails expanding the response repertoire. 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), leading to a higher responding capability of the unit. Knowledge exploration also helps units to offer responses that are heterogeneous in nature because diverse knowledge pools allow units to respond in more than one way (Chi et al., 2007). This is important because it facilitates 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 manifests a greater understanding of market dynamics and results in a higher responding capability. Hence, we propose:

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

Research method

The unit of analysis for this study is the business unit. We needed respondents who had knowledge about both the internal as well as the external aspects of the business unit. 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 and their operations interact extensively with each other as well as with outside vendors (Raschke, 2010; Tracey et al., 2005).

The data were collected from an opt-in panel of respondents managed by a reputable data collection company that specializes in business-to-business research and data collection. 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). The survey was administered via a Web-based survey with screening questions in the survey to reduce sampling error. We received 303 complete responses from a sample frame of 1222, yielding a response rate of 24.7%. 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.

Measures

Existing measurement items of previously validated scales were adapted to measure the constructs. Measures were adapted to fit the context of our research model (Churchill, 1979). The measures were refined through two card-sorting rounds with academic expert panels. This allowed us to assess the content validity of the measures. 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 industry experts understood the survey as intended by the researchers. Due to the changes that we made to the original items during this process, our items are an adapted form of the items used by the original sources (see Appendix A for details about pre-testing and administration of survey). The constructs and their definitions are shown in Table 1 (in the theoretical background section). Appendix B lists the construct measurement items along with their sources. The following sections present conceptualization and definitions of the constructs.

Electronic Integration was measured as the extent to which IS applications of a unit work as functional whole in conjunction with each other (Saraf et al., 2007). 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). Since electronic integration can be achieved by a 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. Following prior literature, we used reflective scales to measure internal and external electronic integration.

Process coupling is defined as the intermeshing of process activities such that they are operationally coordinated (Saraf et al., 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. A reflective scale based on the works of Saraf et al. (2007) and Rai et al. (2006) was used to measure our process coupling constructs.

We conceptualize *knowledge exploration* as gaining new knowledge from sources outside of the business unit, such as downstream customers, retailers, and distributors. Exploration is 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; Subramani, 2004). It has been characterized as a distance search for new capabilities, often carried out external to the organization (Benner and Tushman, 2003; Raisch et al., 2009). Exploration involves accessing and understanding information that was previously not possessed by a business unit. It involves accessing new knowledge domains by transfer of knowledge from external sources (partners, alliances) (Benner and Tushman, 2003; von Krogh et al., 2001). Although it can be argued that knowledge accessed external to the business unit is not necessarily novel, it must be noted that it is new knowledge for the focal business unit. 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 based this construct on the extant knowledge exploration literature and conceptualized it as a reflective construct. We adapted measures from the works of Malhotra et al. (2007) and Im and Rai (2008) to measure knowledge exploration.

Knowledge exploitation is the process of adopting, synthesizing, and applying current or existing knowledge (Liu, 2006). It involves retrieving knowledge that has already been created and internalized within a business unit. However, this knowledge needs to be combined and drawn upon to be effective. It has been characterized as a local search that capitalizes on existing capabilities, often carried out internal to the organization (Im and Rai, 2008). 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, 2003; von Krogh et al., 2001). Knowledge exploitation is conceptualized as a reflective construct and assesses the extent to which a business unit leverages knowledge internally from its subunits. The extant 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 based our construct on the works of Malhotra et al. (2007) and Im and Rai (2008) to capture the product and markets dimensions.

The 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 (Fink and Neumann, 2009; Oosterhout et al., 2006; Tallon, 2008). We incorporate both the sensing and responding elements of agility. Sensing is the capability to detect changes and developments in the external environment (such as the customer environment, the market environment, or the competitor environment). Responding is the capability of the business unit to respond to changes in demand, new product development, change in product mix, product pricing, market expansion, change in process capabilities, and supplier selection. We adapted Tallon's (2008) and Raschke's (2010) measurement items to operationalize the sensing and responding as reflective constructs.

Our decision to select reflective constructs instead of formative ones is based on two considerations. First, although our respondents came primarily from the manufacturing industry, we expect their business context to be highly diverse (e.g. electronics manufacturing, industrial equipment manufacturing, fabricated metal, plastics, etc.). This makes creating formative constructs that are grounded in their specific business context nearly impossible (Saraf et al., 2007). Hence, we used reflective scales that allow the respondents to interpret survey items in their specific business context. Second, prior literature argues that these constructs can be seen as capabilities that influence (cause) the scores of the measured items thus making them reflective constructs. For instance, for a business unit that is responsive to changes in its business environment, its responsiveness would reflect a higher score in its capability to respond to changes in demand, new product development, changes in product mix, supplier selection and so on. We note that the primary references for all our constructs (e.g. Im and Rai, 2008; Malhotra et al., 2007; Saraf et al., 2007; Rai et al., 2006; Raschke, 2010; Tallon, 2008) have used reflective measures to operationalize these constructs.

Data analysis

We chose SmartPLS to do the data analysis using a partial least squares (PLS) technique. 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 (6×10). 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. The primary reason for choosing PLS as the analysis technique is that 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). Hence, we chose PLS as our data analysis technique.

Results

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%). 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 (see Table 2).

Measurement Model Validation: 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 3. To assess convergent validity, we examined the standardized loadings from the PLS output. The standardized loadings should be above 0.707 for appropriate levels of convergent validity (Fornell and Larcker, 1981).

Table 4 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 did 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.

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 4 (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 had a higher loading with its own construct compared to its loading with the other constructs (see Table 4 above). At the construct level, we verified that the correlations between constructs were lower than the square root AVE of the focal construct. This is shown in Table 5.

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 significantly lower than the AVE for associated items for each construct (see Table 6). This result further confirmed construct validity (Fornell and Larcker, 1981).

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., 2011) and even the more stringent 3.33 thresholds.

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, 2010). Fig. 3 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

Table 2
Sample characteristics.

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%

Table 3
AVE and composite reliability.*

	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

* EEI: External Electronic Integration; EPC: External Process Coupling; IEI: Internal Electronic Integration; IPC: Internal Process Coupling; KER: Knowledge Exploration; KET: Knowledge Exploitation; MORT: Market Orientation; RES: Responding capability; SEN: Sensing capability.

levels of significance. As shown in Fig. 3, all hypotheses were supported at the 0.001 level, except for H5. 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.

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. In addition, 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 relation with responding (β = 0.187, t = 2.055). Then we tested the indirect relation from internal electronic integration to the mediator variable knowledge exploitation (β = 0.381, t = 6.947) and from knowledge exploitation to responding (β = 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 (β = −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 (β = 0.187, t = 2.055). After adding internal process coupling, the path between internal integration and internal process coupling was significant (β = 0.552, t = 10.463) but the path between internal process coupling and responding was not significant (β = 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 relation between internal electronic integration and sensing was not significant (β = 0.072, t = 0.973). The indirect path, however, was significant as the path from internal electronic integration to knowledge exploitation was significant (β = 0.373, t = 5.959) and so was the path from knowledge exploitation to sensing (β = 0.155, t = 1.705) at the 0.10 level. The direct path 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 path 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 path 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

Table 4
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

added the direct path reduces in strength but remains significant ($\beta = 0.188$, $t = 1.843$) at the 0.10 level. The indirect path, consisting of the paths from external electronic integration to knowledge exploration ($\beta = 0.630$, $t = 11.245$) and from knowledge exploration to sensing ($\beta = 0.222$, $t = 2.570$), are significant. The results of mediation analysis using the Barron and Kenny (1986) approach are shown in Table 7.

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. We systematically removed the mediators for paths with multiple mediators to test the role 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 (Preacher and Hayes, 2008). If the direct path is insignificant while the indirect path is significant, we conclude in favor of mediation. The results of this test were same as those attained from Barron and Kenny (1986)

Table 5
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**

Table 6
AVE for associated and non-associated items.

	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

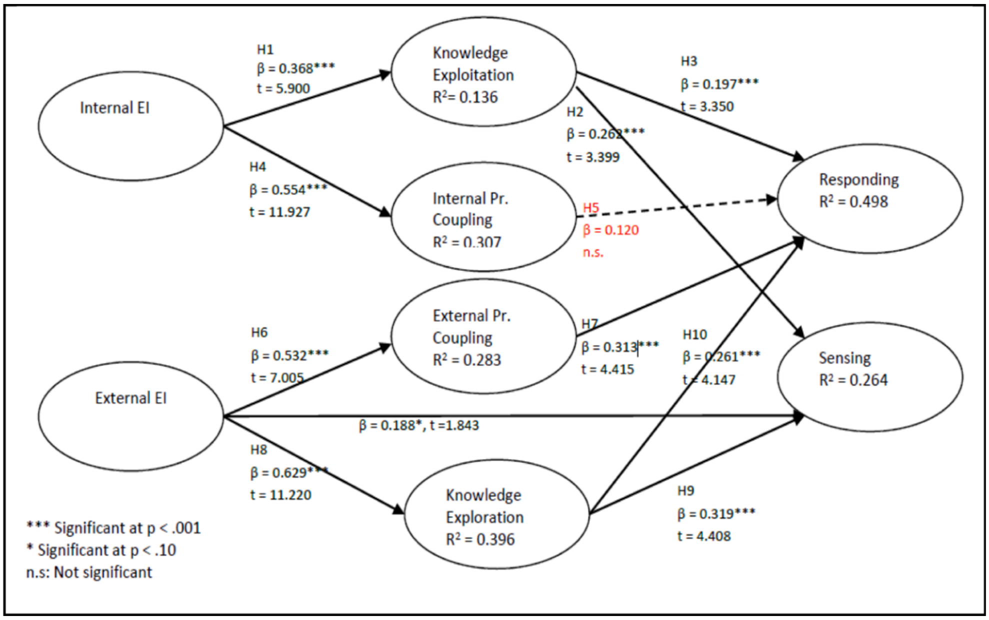

Fig. 3. Path coefficients and variance explained.

approach detailed above (see Table 8 below).

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

Table 7
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 path remains significant at the 0.10 level while the indirect path is also significant.

Table 8
Mediation analysis results using bootstrapped approach (Preacher and Hayes, 2008).

Relationship	Direct path	Indirect path	Conclusion
IEI → KET → RES	$\beta = -0.0303$, $t = 0.4062$	$\beta = 0.0713$, $t = 2.4261$	Since the direct path is nonsignificant and indirect is significant, this is mediation
IEI → IPC → RES	$\beta = -0.0082$, $t = 0.1093$	$\beta = 0.0613$, $t = 0.9482$	Since both paths are insignificant, there is no mediation
IEI → KET → SEN	$\beta = 0.155$, $t = 1.2313$	$\beta = 0.1457$, $t = 2.0047$	Since the direct path is nonsignificant and indirect is significant, this is mediation
EEI → EPC → RES	$\beta = 0.0203$, $t = 0.2446$	$\beta = 0.1852$, $t = 2.0554$	Since the direct path is nonsignificant and indirect is significant, this is mediation.
EEI → KER → RES	$\beta = 0.0234$, $t = 0.2807$	$\beta = 0.1836$, $t = 2.6497$	Since the direct path is nonsignificant and indirect is significant, this is mediation.
EEI → KER → SEN	$\beta = 0.1900$, $t = 1.7381$	$\beta = 0.3298$, $t = 3.5633$	Shows partial mediation. The indirect path is significant at 0.01 level and the direct path is significant at the 0.10 level.

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).

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 9 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. In addition, knowledge exploration fully mediates the relation between external electronic integration and responding but partially mediates the relation between external electronic integration and sensing.

Table 9
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

Discussion

As the capabilities to sense and respond to change have grown in importance due to increasing competition, the need to have integrated systems that provide unfettered access to data, information and knowledge has also grown (Lu and Ramamurthy, 2011). Despite the increasing importance of integration and agility, these two research streams have developed independently without a clear understanding of how integration would relate to agility. The objective of this research was to fill this gap by empirically exploring this relation using coordination theory as our guide.

Past literature suggests that firms may have to forego full internal and external integration benefits in order to stay agile (Rossetti and Choi, 2005; Swink et al., 2007). Our results cast doubt on that idea and show that integration is positively associated with agility. Taking a broad and aggregated view of the integration-agility relation hinders our ability to understand this phenomenon and can lead to conflicting perspectives. Instead, by developing a fine-grained model that links the components of integration and agility and by drawing on coordination theory, we were able to examine the relationship between integration and agility. We found that the two types of integration (internal and external) actually have differential impacts on the sensing and responding capabilities of agility. Internal electronic integration positively relates to the responding and sensing capabilities through the mediating role of knowledge exploitation. Interestingly, even though internal electronic integration positively relates to process coupling, those effects do not transfer to responding capability. Although the theoretical argument that process coupling is positively associated to the responding capability of business units makes much sense, there is a need to take a deeper look into this phenomenon in order to understand the specifics of how this relation 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 may fail to positively affect responding capability (Bharadwaj, 2000; Saraf et al., 2007). Moreover, it is also possible that high process coupling allows 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). External electronic integration positively relates to responding capability through both external process coupling and knowledge exploration. Both variables fully mediate the relation between external electronic integration and responding. This is consistent with the idea that, in addition to knowledge exploration, process coupling is also important in providing the capability to respond to environmental change (Braunscheidel and Suresh, 2009, Gunasekaran et al., 2008).

While previous research has indicated that integration has a direct effect on the sensing and responding capabilities, we investigate the nomological network in which knowledge and process constructs mediate the integration-agility relation thus helping us explain *why* integration is positively associated with sensing and responding. Our findings support the idea that external electronic integration is directly associated with the sensing capability of business units and indirectly associated through the mediating role of knowledge exploration. The support for both direct and indirect association is interesting. It means that business units are able to sense changes in the environment as they go through the process of electronic integration with their external partners as well as when they formally make the effort to explore the knowledge that is embedded in their partner network. It is possible that electronic integration with external partners is directly associated with 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).

Past research on agility has focused on the IT infrastructure as a broad and holistic construct that facilitates capability building (Chen et al., 2014; Fink and Neumann, 2009). As a result, we lack a deeper understanding of how specific aspects of the IT infrastructure relate to the sensing and responding components of agility individually (Roberts and Grover, 2012). Our paper fills this gap by focusing on the integrational capability of technology and its relation to the sensing and responding capabilities of business units. Overall, our study shows that internal and external electronic integration have a strong relation with the sensing and responding capabilities of business units and that this relation is enabled through the mediating roles of process coupling as well as knowledge exploration and knowledge exploitation.

Contributions

This study contributes to the integration-agility literature in three ways. First, it contributes by connecting integration and agility streams of research that have developed in parallel without much attention to how integration relates to agility. Most agility research has focused on broad IT constructs - such as IT capability (Chen et al., 2014; Lu and Ramamurthy, 2011), the technical ability of IT personnel (Fink and Neumann, 2007), and the business and IT alignment (Tallon and Pinsonneault, 2011) – and their impact on agility. Although these are important, there is also a need to investigate the relation between integration and agility especially due to the fact that organizations have invested heavily in gaining integration as well as agility. Using coordination theory as our guide we provide empirical evidence that suggests that integration is positively associated with the sensing and responding capabilities.

Second, it contributes by investigating integration's relation with 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 increasingly competitive 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 relation between integration and 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 investigated the role of the mediating variables that facilitate the relation between integration and the sensing and responding capabilities of agility. In essence, our proposed model delineates the individual role of two types of integration on the individual sensing and responding elements of agility through specific knowledge and process constructs. Our study provides strong support for the argument that integration has a positive relationship with sensing and responding capabilities, which is enabled through the mediating role of the knowledge, and process constructs.

Our paper also contributes to practice. First, our results indicate that integration of IT assets is, in fact, positively associated with sensing and responding capabilities of organizations. With several conflicting arguments found in the extant literature, managers could have easily been misguided to think that too much integration could impair agility. This study provides evidence that will enable managers to confidently strive to achieve the full benefits of integration rather than foregoing those benefits out of wariness that integration might cripple their organization by creating core rigidities. Second, and perhaps more importantly, this study shows the distinct pathways from integration to sensing and responding capabilities through knowledge sharing and process coupling. This provides a nuanced understanding of the relational pathways through which integration is associated to sensing and responding. Appreciation of these relational pathways could help managers decide upon investment strategies that allow them to establish stronger relations with their internal and external partners and potentially help managers target specific capabilities of agility. Finally, our study highlights the idea that investments in knowledge sharing and process coupling behaviors within and outside the organization can provide a platform that helps firms attain higher levels of sensing and responding capabilities. Managers should mindfully develop knowledge and process capabilities such that they can draw the maximum potential benefits from their partners in their intra- and inter-enterprise partner networks.

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 kept at a functional level rather than at a technical level, respondents in the business domain can adequately respond to IT-related questions (Rai and Tang, 2010; Saraf et al., 2007). By making this careful adjustment to our questions, we believe the respondents from a business domain were able to leverage their functional knowledge in answering technology-related questions. Moreover, we also made sure that the informants were experienced enough to know their business context well. Out of the 303 respondents, 206 were senior to executive level managers and 93 were mid-level managers. The average experience of the respondents in their current position was 6 years. With all these safeguards in place, we believe our respondents were knowledgeable enough about the level of agility as well as the level of integration and process coupling in their specific context.

Second, using a single respondent to provide responses to both independent and dependent variables raises some concerns of common method bias. We have taken several steps to reduce the effects of common method bias (as detailed in the methods section). 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). This unclear relation could also be an indication of the ambivalent outcomes of integration. Since our current research design does not allow us to investigate this phenomenon any further, additional research is needed to better understand the effects of process coupling as well as the ambivalent outcomes of integration.

Future research

There are several 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 could allow a further understanding of how integration impacts agility over time. 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 with external partners using a longitudinal design.

Second, although our study focused on the manufacturing organization, future research should explore the integration-agility relation by including 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 future research to explore the benefits of integration from several different perspectives and allow triangulation of data from several sources.

Third, 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 (Saraf et al., 2007). 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. Including other antecedents may lead to deeper insights into the integration-agility relationship. Future research should also explore a contingency view of the impact of integration on agility. Examining the conditions under which the relationship between integration and agility might vary is important to gain a deeper understanding of the integration-agility relationship which may be impacted by other organizational factors such as organizational culture, business and IT strategy and collaborative capabilities. The contingency perspective of research suggests that the value of IT should be studied in conjunction with a firm's strategy (Kohli and Devaraj, 2004). Similarly, the degree to which a firm attains agility might also be related to the degree to which organizational culture and collaborative capabilities play a moderating role between integration and agility. Although our research shows that integration helps attain agility, future research should explore the moderating role of other factors, such as organizational strategy, culture and collaborative capabilities.

Fourth, since this study relied on cross-sectional data, we can argue for the effect of integration on agility based only on theoretical arguments and are unable to claim with certainty that the direction of the relations is exactly as we have proposed. It is possible to argue that the direction of causality is in the opposite direction. Although we believe that the extant literature strongly supports the proposed directions of causality in the research model, the reverse argument that agility might have encouraged integration, should be investigated further.

Finally, our research methodology limited us to using a variance perspective to investigate the relationship between integration and agility. Future research should take advantage of more dynamic perspectives such as process and systems perspectives (Burton-Jones et al., 2015) in order to gain a deeper understanding of the integration-agility relationship. Using such a perspective can help study the integration-agility relationship as set of interacting parts and emergent properties, where business units are considered to have properties such as internal and external integration capabilities that affect the sensing and responding capabilities of the unit. The sensing and responding properties can, in turn, affect the organization and change the degree to which management pursues integration. In essence, this would enable future research to be sensitized to feedback loops that allow parts of a system to affect the whole organization (Burton-Jones et al., 2015)[3].

Conclusion

The capabilities of sensing and responding have become important dynamic capabilities in the current competitive environment. Meanwhile, integration of enterprise systems has also garnered tremendous importance. The two research streams have developed independently without informing each other much. Due to this reason, companies may find themselves in a quandary where they may be unsure about whether integration enables or hinders agility. Some theoretical perspectives have the potential to argue for both an enabling as well as a disabling role of integration on agility. Using coordination theory, we were able to tease out the role of internal and external electronic integration on the individual sensing and responding capabilities through knowledge and process mediating constructs. Our results suggest that internal and external integration are key capabilities strongly associated to business unit agility, and knowledge exploitation and internal process coupling play an important role in this relation. Moreover, knowledge exploration and external process coupling play a partial mediation role on the sensing and responding components of agility. We hope this study stimulates further discussion with regards to the role of other IT constructs such as flexibility and reusability and that it advances theory to further understand the IT-agility relation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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[3] We thank the review team for this suggestion about using a process or systems dynamic approach in future research.

Appendix A. Construct validity and survey administration procedure

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.

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. In the first round of card sorting, items that received an average agreement level of less than 70% were dropped. 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. 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.

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.

Survey administration

The survey was administered using a web-based survey approach. Screening questions were included in the questionnaire to ensure reduced sampling error. The questions asked the respondents about their job role in their organization. Specifically, the screening questions asked whether the respondents interacted with external and internal stakeholders in their job. Respondents were also asked whether they 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).

Appendix B. Construct measures

External Electronic Integration (Rai et al., 2006; Saraf et al., 2007)

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 business unit's closest long-term suppliers and customers) (1 = Not at all, 5 = To a great extent):*

1. Definition of key data elements (e.g. customer, order, part number) are common among our applications and the applications of our external partners.

2. Same data (e.g. order status) stored in different databases are consistent across our applications and those of our external partners.

4. We can easily share our data with our external partners.

5. We have successfully integrated most of our applications with the applications of our external partners.

6. Our internal applications (such as our enterprise resource planning application) communicate in real time with the applications of our external partners.

7. Most of our applications work seamlessly with the applications of our external partners.

8. Our systems can easily transmit, integrate, and process data from our external partners.

External Process Coupling (Rai et al., 2006; Saraf et al., 2007)

*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)* (1 = Not at all, 5 = To a great extent):

1. The business procedures and routines of our unit are highly coordinated with procedures of our external partners.

2. To operate efficiently, we rely on procedures and routines of our external partners.

3. Our way of doing business is closely linked with that of our external partners.

4. Most of our operations are closely connected with the operations of our external partners.

5. To facilitate operations, our business procedures and routines are linked with those of our external partners.

6. To arrive at demand forecasts, we collaborate with our external partners.

Internal Electronic Integration (Rai et al., 2006; Saraf et al., 2007)

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 (1 = Not at all, 5 = To a great extent):

3. We can easily share our data with each other.

4. We have successfully integrated most of our IT applications.

5. Most of our IT applications work seamlessly across units.

7. Our applications easily transmit, integrate, and process data among each other.

Internal Process Coupling (Rai et al., 2006; Saraf et al., 2007)

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 (1 = Not at all, 5 = To a great extent):

1. The business procedures and routines are highly coordinated with each other.

3. Our way of doing business is closely linked with each other.

4. Most of our operations are closely connected with each other.

5. Our business procedures and routines are linked with each other.

6. Production and delivery schedules are shared among processes.

Knowledge Exploration (Im and Rai, 2008; Malhotra et al., 2007)

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)* (1 = Not at all, 5 = To a great extent):

1. Extent to which we obtain new knowledge about building new products from our external partners.

2. Extent to which we obtain details of upcoming product related changes from our external partners.

3. Extent to which we obtain details of changes in product features or volumes from our external partners.

4. Extent to which we obtain knowledge about new business opportunities from our external partners.

6. Extent to which we obtain knowledge of demand shifts and changes in customer preferences from our external partners.

7. Extent to which we obtain knowledge related to demand trends and forecasts from our external partners.

8. Extent to which we obtain knowledge from external partners that helps us better understand the capabilities and intentions of competitors our external partners.

Knowledge Exploitation (Im and Rai, 2008; Malhotra et al., 2007)

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 (1 = Not at all, 5 = To a great extent):

1. Leverage existing knowledge from each other to improve products.

2. Obtain knowledge from each other about changes in product features or volumes.

3. Obtain process knowledge from each other to support changes in product features or volumes.

4. Obtain knowledge from each other of future plans such as promotion and marketing plans, capacity utilization.

5. Obtain details of demand trends and forecasts from each other.

6. Obtain details of demand shifts and changes in customer preferences from each other.

Market Orientation (Saraf et al., 2007; Kohli and Jaworski, 1990)

Please indicate the extent to which you agree with the following statements: (1 = Not at all, 5 = To a great extent):

1. Business strategies are driven by the goal of increasing customer value.

3. Our philosophy of doing business is driven by the need of putting customers first.

4. Customer preferences change rapidly for our products.
6. There is intense competition for market share in our product market.
8. Technological innovations have brought many new product ideas to our product market in the recent past.

Responding Capability (Raschke, 2010; Tallon, 2008):

To what extent can your business unit easily and quickly perform the following business actions (1 = Not at all, 5 = To a great extent):

1. Respond to changes in aggregate consumer demand.
2. Customize products or services to suit individual customers.
3. React to new product/service launches by competitors.
4. Introduce new pricing schedules in response to changes in competitors' prices.
5. Expand into new regional and international markets.
6. Change (i.e. expand or reduce) the variety of products / services available for sale.
7. Adopt new technologies to produce better, faster and cheaper products and services
8. Switch suppliers to avail of lower costs, better quality or improved delivery times.
9. Successfully and quickly change functionality of business process.

Sensing Capability (Raschke, 2010; Tallon, 2008)

To what extent can your unit easily and quickly perform the following actions (1 = Not at all, 5 = To a great extent):

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

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