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# Leveraging Standard Electronic Business Interfaces to Enable Adaptive Supply Chain Partnerships

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Adaptive supply chain partnerships are a key factor in driving the ability of extended enterprise partners to achieve long-term goals in an environment characterized by disruptive environmental shifts. Adaptive extended enterprise arrangements allow participating enterprises to leverage their combined assets for collective exploration and exploitation. In the context of extended enterprises, where significant investments have been directed toward instituting common interfaces, this study examines the question: *How does the use of standard electronic business interfaces (SEBIs) enable supply chain partnerships to become more adaptive?*

This study conceptualizes the use of SEBIs as a boundary-spanning mechanism that helps overcome boundaries that impede knowledge transfer between enterprises in supply chains. SEBIs enables partners to gain insight into their broader environments, enriching each partner's perspective (enhanced *bridging*). SEBIs also help strengthen the cooperative ties between partners, motivating each partner to adapt for collective gain (enhanced *bonding*).

Our research model is empirically tested using data collected from 41 demand-side supply chain partnerships (between original equipment manufacturers (OEMs), distributors, and retailers) in the information technology (IT) industry. The results show that collaborative information exchange (CIE) between supply chain partners mediates the relationship between use of SEBIs and *mutual adaptation* (MA) and adaptive knowledge creation between supply chain partners. Interestingly, the use of SEBIs is found to be directly associated with MA but only indirectly associated with adaptive knowledge creation.

The study points out that the strategic impacts of SEBIs go well beyond the exchange of transaction information and process integration. It also shows that multilateral, quasi-open, and information exchange-and process linkage-oriented SEBIs can result in both bonding and bridging across supply chain partners without binding them inflexibly to specific partners. Based on the model and results, the study offers practical implications for how SEBIs should be developed, adopted, and used.

**Key words:** standard electronic business interfaces; boundary objects; supply chain partnering; adaptive partnerships; adaptation; digitally enabled extended enterprise; bridging; bonding

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## 1. Introduction

Today's hypercompetitive environment, characterized by changing customer preferences, shifting industry boundaries, and emerging global competition, requires enterprises to build capabilities for constant innovation and to respond to competitive pressures from unforeseen new sources (D'Aveni 1994, Brown and Eisenhardt 1997). This has been accompanied by

an unbundling of economic activity driven by falling transaction costs, as information and communication technologies facilitate connectivity across enterprises (Hagel and Singer 1999). Unbundling requires enterprises to rely on specialized partners for complementary activities. Such partnerships, constituting the *extended enterprise*, are a source of relational rents and competitive advantage (Dyer 1996, 1997; Dyer and

Singh 1998). The value creation potential of extended enterprise relationships can be leveraged to pursue new opportunities and to better adapt to market changes (Young-Ybarra and Wiersema 1999; Kopczak and Johnson 2003; Malhotra et al. 2001, 2005; El Sawy et al. 1999).

In supply chains, interorganizational relationships are continually restructured to pursue higher-order goals (beyond achieving transactional efficiencies), such as faster market entry, new market development, and interorganizational learning, that are the basis for long-term viability (Eisenhardt and Schoonhoven 1996, Gosain et al. 2004). A key factor driving the ability of the extended enterprise to achieve long-term goals in an environment characterized by disruptive environmental shifts is *adaptability* (Rindova and Kotha 2001).

To some extent, an enterprise may rely on its ability to reconfigure internal competencies. However, the need for change in an era of interdependence among enterprises requires joint adaptation by both the enterprise and its partners. Consider, for example, the need for a manufacturer to refresh product offerings in volatile environments. This requires intermeshed new product introduction processes that span the manufacturer, wholesale distributors, and retailers. Supply chain partnerships also provide opportunities for enterprises to learn from their partners to better adapt to high-velocity market environments. Therefore, in this paper we refer to *adaptive supply chain partnerships* as those in which firms constituting the extended enterprise: (a) adjust their procedures, processes, and structures to suit each other and (b) leverage each others' knowledge resources to create the knowledge required to adapt to the market environment.

Interenterprise electronic interconnections that are architecturally sound (from a technical as well as business perspective) allow exploitation of new opportunities through digital enablement of extended enterprises. The quest for transactional efficiencies and automated business process integration between applications and across supply chain partners has created the necessity for the use of SEBIs. The current generation of multilateral, quasi-open, and extensible SEBIs (see Wigand et al. 2005 for a case study in the home mortgage industry) that support structured

interenterprise process interfaces may also be a way to make extended enterprise more adaptive.

The first generation of SEBIs, adopted in the 1980s with electronic data interchange (EDI), took the form of message standards that allowed computer-to-computer exchange of structured information around transactions. However, EDI-type SEBIs had disadvantages in terms of inflexibility and cost, and adoption of such standards was limited to applications related to purchasing processes. Consequently, EDI-type SEBIs had fairly limited impact in transforming enterprises and interenterprise relationships. The second generation of SEBIs triggered in 1998 by the RosettaNet Consortium is structurally different, comprising both business process standards, called partner interface processes (PIPs), as well as data dictionary standards for product descriptions and specifications. This allows many-to-many electronic connectivity relationships and heralds a much richer and more flexible form of business process connectivity across enterprises.

Further, interorganizational connectivity is aided in technical implementation and flexibility by the development of XML (extensible markup language) and associated technologies.<sup>1</sup> The emergence of flexible markup formats and connectivity infrastructure has provided an impetus to various enterprises to participate in industry consortia to collaboratively develop new standards (e.g., Rosettanet standards). These second-generation SEBIs go beyond standardizing information exchange by also standardizing interenterprise process linkages (Gosain et al. 2003). These standards have brought about the potential for new opportunities and pathways for changing the way digitally enabled extended enterprises can work together, develop new competencies, and manage their partnering relationships.

We propose that the use of SEBIs has a significant impact on the adaptiveness of the extended

<sup>1</sup> Please see the e-companion to this paper for a detailed comparison of XML-based SEBIs to EDI-type SEBIs. The e-companion is available on the *Information Systems Research* website (<http://isr.pubs.informs.org/ecompanion.html>). The comparison also highlights the definition of second-generation SEBIs. The electronic supplement also presents a background for RosettaNet.

enterprise by shaping information exchanges and processes between enterprises. Standards lay out the document schemas and the conditional choreography of document exchanges needed to complete a business process extended across multiple enterprises. At the same time, these standards afford enterprises the flexibility of customizing some process-related parameters to adapt to the requirements of their partners. Further, deployment and use of such standards enable enterprises to simultaneously exchange information with multiple extended enterprise partners. Such an exchange would otherwise have required extensive effort in one-to-one customization of information exchange parameters. We view the SEBIs as templates that inscribe broad patterns of information exchange in interenterprise systems, allowing freedom for enterprises to respond to change, yet prevent exchanges from becoming entirely idiosyncratic to a relationship. This study seeks to examine the following research question: *How does the use of SEBIs enable adaptive supply chain partnerships?*

While the potential gains from adaptive interorganizational linkages are apparent, the nurturing of these capabilities is not easy. A significant challenge is that enterprises may, over time, develop sticky patterns with entrenched partners, and these may be very resistant to change (Van den Bosch et al. 1999). Also, it can be argued that enterprises face a trade-off between reach and richness in terms of their external partnerships (Fjeldstad and Haanaes 2001). Therefore, enterprises can either maintain short-term transactional contracts with a large number of suppliers or long-term relational contracts with a few suppliers (Madhok 2002, p. 544). This implies two types of barriers: not knowing enough about a partner and its specialized domain or processes (lack of *bonding*) or being too bound with a partner to be able to maintain diversity in perspectives (lack of *bridging*).

In addressing the central research question in this study, we draw on recent theoretical work related to boundaries that impact knowledge transfer (Carlile 2002, 2004) to conceptualize SEBIs as a boundary-spanning mechanism that motivates and enables collaborative information sharing across enterprise boundaries. Further, we view CIE as an important mediating mechanism for the realization of adaptive supply chain partnerships. Supply chains are shifting

their focus from the efficient movement of physical products toward information exchange to better adapt to their market environments (Patnayakuni et al. 2006, Rai et al. 2006, Straub et al. 2004). CIE has been shown to be a key factor in the creation of shared knowledge in supply chains (Malhotra et al. 2005), which in turn is essential for adapting to environmental changes (Kraatz 1998). The paper develops a perspective of SEBIs as boundary objects that (a) can help partners build adaptable partnerships by leveraging and strengthening their ties (bonding) and (b) can enrich the partners' perspectives by enabling them to gain access and insight into their broader environments while adapting to partnering requirements (bridging).

## 2. Theory Development: Using SEBIs as Boundary Objects in Adaptive Partnerships

Although past research has largely tended to adopt an enterprise-level view to explore how organizations adapt in response to technological innovation and environmental transformations (Koberg 1987, Boeker and Goodstein 1991, Kraatz and Zajac 1996), there has been an increasing interest in understanding how adaptation occurs in interorganizational relationships (Kraatz 1998, Heppard 1998). Interorganizational relationships can be supported to enhance the ability of enterprises to adapt to their changing environment (Ring and Van de Ven 1994) and improve performance (Heppard 1998). In this study, we focus on the adaptive supply chain relationship as a type of dynamic capability that allows enterprises to leverage their partnerships to adapt to the changing business environment.

Recent work suggests the need for *boundary objects* to sustain the intense collaboration and knowledge sharing demanded across enterprise boundaries, particularly in novel environments (Carlile 2004). Interenterprise linkages require

the construction of shared commitments (common ground or common knowledge), and the use of various boundary-spanning mechanisms (e.g., routines, languages, stories, repositories, and models). Developing these commitments and mechanisms requires forging agreement around standard procedures, shared protocols, or boundary objects. (Kellog et al. 2006, p. 24)



Drawing on these ideas, we propose that SEBIs can be a key facilitating mechanism (a boundary object) to help enterprises achieve adaptive supply chain partnerships.

## 2.1. Characterizing Adaptive Supply Chain Partnerships

Organizational theorists, drawing on biological theories, have used the concept of adaptation to study organizational changes in response to shifts in their environment (Burns and Stalker 1961, Chandler 1962, Sharfman and Dean 1997). Past research has found that the ability to continually adapt is an important capability conferring competitive benefits (Brown and Eisenhardt 1997). Contingency theorists advocate that for organizations to survive and thrive, their structure and processes have to be adjusted to suit their environment (Hage and Aiken 1970). In essence, adaptation is an organizational process through which procedural, process, and structural adjustments are made to match the requirements of the environment (Lawrence and Lorsch 1967, Koberg 1987). Theorists have also stressed the importance of learning- and knowledge-creating routines that allow organizations to adapt to their environment (Eisenhardt and Martin 2000, Kraatz 1998).

Adaptation in supply chain partnerships is analogous to the biological concept of symbiotic adaptation—adaptations that occur between two organisms that are interdependent on each other for the purpose of joint benefits (Hallén et al. 1991). Adaptive partnerships are those in which both agents gain by working in conjunction to respond to the mutual challenges they face (Dent 2003). Partners seek ways to mutually adapt and prosper in an environment characterized by changing market conditions and customer needs (Dent 2003, Tang 2005). Sharing of know-how between partners is another salient characteristic of adaptive supply chain partnerships (Tang 2005).

In essence, adaptive supply chain partnerships require mutually beneficial adjustments (Hallén et al. 1991) and joint learning to sense and respond to market environment changes in conjunction with partner enterprises (Kraatz 1998, Malhotra et al. 2005).

**2.1.1. Mutual Adaptation in Supply Chain Partnerships.** Research on alliances has identified that their flexibility is determined by the ability of the

partners to adjust their behaviors or the terms of the alliance agreement in response to changes in the environment or needs of their partners (Young-Ybarra and Wiersema 1999). We refer to the outcome of this ability as MA. A key requirement for such strategic behavior is that the enterprises be motivated toward collective action. Leana and Van Buren (1999) refer to this element as associability: "...ability of participants in an organization to subordinate individual goals and associated actions to collective goals and actions" (p. 541). Associability requires not only establishing collective goals, but also affecting collective action. Therefore, associability is manifest in MA, which denotes the extent to which supply chain partners engage with each other in a responsive and structurally flexible manner (Brennan et al. 2003). Such relationship-specific adaptations also signal long-term orientation and commitment (Bensaou and Venkatraman 1995, Cannon and Perreault 1999).

**2.1.2. Adaptive Knowledge Creation in Supply Chain Partnerships.** As competition increasingly becomes knowledge based, enterprises are leveraging their interorganizational relationships for knowledge creation (Hamel 1991, Huber 1991). Interorganizational networks are fertile grounds for learning that enable the collectivity to learn, adapt, and survive turbulent environments (Haveman 1992, Ingram and Baum 1997). By acquiring and grafting knowledge from external sources, organizations can create new knowledge (Malhotra et al. 2005) and adapt to their environment (Kraatz 1998). Adapting to the market environment requires that companies sense the need for and develop new capabilities, as well as enhance existing capabilities. Successful adaptation is enabled by the development of relevant knowledge to understand the market environment, diagnose current capabilities, anticipate future needs for capabilities, and redesign underlying processes (Day 1994). Supply chain partners can help each other better interpret market signals as well as develop the knowledge requisite for adaptation (Malhotra et al. 2005).

Traditional roles in the supply chain are being reconfigured, so that distributors are taking on the assembly of products, assemblers are taking on a proactive stance in marketing in conjunction with retailers, and retailers are helping design products and services. In this evolution, supply chain players are

highly dependent on partners to keep them apprised of the new roles of channel players. To take on some of these new roles, supply chain enterprises are also beginning to emulate the internal processes of their successful partners and are redesigning their interorganizational processes by leveraging the knowledge gained from their partners.

Supply chain partnerships can be leveraged to create two distinct types of adaptive knowledge: (a) sensing related—understanding of patterns related to the external market (key markets, customers, competitors, or suppliers) (Gupta and Govindarajan 1991) and (b) response related—execution skills and capabilities. Market-related knowledge manifests itself in market responsiveness and the development of innovative products and services. The creation of knowledge related to execution enables organizations to adjust interorganizational processes and structures to collectively capture new opportunities (Malhotra et al. 2001, 2005).

## 2.2. Adaptive Partnerships and CIE

Sensing and responding to the market environment requires rich information (Eisenhardt and Martin 2000). Using information obtained from business partners, enterprises can improve their understanding of resources, competition, and market needs. This results in a quick awareness of changes and shifts in the external environment. The understanding of the external environment and the creation of new knowledge from the information obtained from business partners can also be translated into decisions and actions that help enterprises adapt to their environment. The new knowledge created through information exchange with partners can be in the arena of design of new products and services, improved existing offerings, and improved delivery through redesigned interorganizational processes (Malhotra et al. 2005). In this study, we conceptualize the sharing of this high-value-added information between supply chain partners as CIE, that is, the exchange of information that is broad-ranging, high quality, and privileged in nature (Malhotra et al. 2005).

**2.2.1. Broad-Ranging Information Exchange.** The development of new capabilities and enhancement of existing capabilities to adapt to the environments requires collaborative information exchange (Nonaka

1994, Malhotra et al. 2005). Understanding of the competitive space, knowledge of how to perform new roles, and development of new capabilities requires the flow of information between partners to go beyond mere information coordination. To make necessary adaptations to suit the environment, enterprises seek broader information from their partners (Brennan et al. 2003). Supply chain players are realizing that to unleash the true potential of the supply chain, they will need to share information such as market trends, changes in customers' preferences, new product introductions, and future product plans that have longer-term implications (Austin et al. 1997). In addition, they need to share information related to process improvements, strategic directions, and new capabilities that could help partners. Along with transaction and coordination information, supply chain partners are requiring each other to provide information about market conditions (Fites 1996).

**2.2.2. Quality of Information Exchange.** Although it is beneficial for partners to exchange a broad range of information, ensuring the quality of information exchange is equally important. Otherwise, enterprises can suffer from an information overload or the "garbage in–garbage out" syndrome. The importance of the quality of information exchange was highlighted repeatedly in our field interviews. For example, an executive at a leading computer manufacturer with an extensive effort under way to improve quality of information exchange expressed it like this:

We are making huge investments to increase the quality of information we exchange with our suppliers and customers, in terms of its coverage, granularity, frequency, and depth. I would like to have depth and detail to the extent that I could tell what location of [major customer] purchased Model XX PCs and who they purchased it from. Currently it is extremely difficult to get POS [point of sale] information about what unit went to which customer.

**2.2.3. Privileged Information Exchange.** The value of information exchange that drives the ability to leverage their partnerships for information exchange depends on partners' perceptions of how specific the information is to the needs of the partner involved in the exchange. As Uzzi and Lancaster (2003) point out, innovations based on interorganizational relationships occur when they allow for the transfer of

idiosyncratic and privileged information. Privileged information can be related to an enterprise's strategy, distinctive competencies, undocumented product capabilities, or critical customer or supplier dependencies. So privileged information goes beyond the collection and reporting of standard information that is symbolic of arm's-length partnerships (Malhotra et al. 2005). Privileged information is specific to the receiving partner and inherently tends to be proprietary and confidential in nature (Cannon and Perreault 1999). Consequently, it provides the partner with a unique perspective not otherwise available. Exchange of privileged—unusually detailed, confidential, or sensitive—information is an important factor in the successful adaptation in interorganizational settings (Brennan et al. 2003).

Adaptive interorganizational partnerships require a greater degree of CIE between partners (Cannon and Perreault 1999). CIE enables organizations to adjust to adapt to changing conditions (Brown and Duguid 1991, Fiol and Lyles 1985). Although environmental shifts create signals for enterprises (Dill 1962), these signals may be weak, confusing, and spurious (Choo 1998). Therefore, broad-ranging, high-quality, and privileged information exchange enables partners to make sense of the environment and make changes in their partnership to respond to the environment.

**HYPOTHESIS 1.** *CIE between partners positively influences MA and adaptive knowledge creation in supply chain partnerships.<sup>2</sup>*

### 2.3. Use of SEBIs as Boundary Objects

Increasingly, enterprises in various industries are forming consortia to develop, adopt, and use standards to support information exchange with partners and improve interorganizational process linkages (Zhao et al. 2005). XML-based standards, such as RosettaNet PIPs, enable enterprises to develop process linkages with business partners that are more adaptable—i.e., that can be changed to meet the needs

of the business environment (Gosain et al. 2004). These standards specify how activities being performed by individual enterprises, as a part of a supply chain process, should be choreographed and coordinated (see e-companion to this paper for a comparison between EDI and XML based standards). In essence, the use of SEBIs refers to an explicit or implicit agreement on common specifications for information-exchange formats and processing tasks at the interfaces between interacting supply chain partners. By virtue of providing explicit or implicit templates linking process and information schema of an enterprise to its partners, SEBIs can act as *boundary objects* (Brown and Duguid 1998, Star 1989).

Boundaries between organizational entities can adversely impact the transfer of information and knowledge. These boundaries arise from the different information (amount and/or type) entities possess, the degree of dependence on the information, and the degree of common understanding/knowledge between those involved in the exchange (Star 1989; Carlile 2002, 2004). To serve as a boundary-spanning mechanism, an object should be both flexible and malleable for actors to fill in the local meaning and vision of use, and sufficiently defined and durable to allow shared use (Neumann and Star 1996). SEBIs fulfill this role by allowing enterprises to map their local meanings and practices to a common referent and then negotiate their differences. Through this common referent the local practices of an organizations are associated with the local practices of the partner organization, which creates an understanding in partner organizations as to how their local actions impact the processes in the partners' organization.

Carlile (2004) suggests three boundaries that influence the transfer of information and knowledge between entities: *syntactic*, *semantic*, and *pragmatic* boundaries. The *syntactic boundary* perspective is rooted in the information processing view of the firm (Lawrence and Lorsch 1967, Galbraith 1973, Tushman 1978). The spanning of a syntactic boundary emphasizes the development of a common/shared language between entities engaged in exchange to enable access and information exchange. According to Carlile (2004, p. 558),

when common lexicon sufficiently specifies the difference and dependencies of the consequence at the

<sup>2</sup> The unit of analysis for this study is a supply chain dyad, where the partner enterprises belong to adjacent tiers of the supply chain (e.g., a manufacturer and a wholesale distributor).

boundary, the boundary proves unproblematic; the primary concern is one of processing or transferring knowledge across it.

However, the development of a common language is a necessary but not sufficient condition for the transfer of information between different entities. The development of a common/shared meaning helps span the *semantic boundary* between entities engaged in information exchange (Dougherty 1990). A shared or common meaning helps overcome any interpretive differences that may exist at the boundary. Boundary objects are a way of managing the tension between divergent viewpoints (Bowker and Star 1999). Organizational entities that develop shared meanings with each other are better able to understand each other's needs. This allows enterprises to exchange information more appropriately and adapt their processes and structures to suit partners' needs. They do not need to expend cognitive resources in translating and interpreting information received from each other (Malhotra et al. 2005).

The final and highest level of boundary that can impede the transfer of knowledge between entities is the *pragmatic boundary*. Spanning a pragmatic boundary requires providing an adequate means for assessing value and therefore sharing information across the boundaries. Carlile (2004, p. 560) emphasizes that "to create common interests to share and assess knowledge across boundaries requires significant practical and political effort."

In our context, at the most basic level, SEBIs enable the spanning of the syntactic boundary between supply chain partners. SEBIs establish a shared language between the partners, which has the potential of increasing the information-processing capacity of the partners (Galbraith 1973). Research also suggests that quasi-open, process linkage and information exchange and multilateral SEBIs are not just vehicles for reducing transaction costs. They also create new collaborative opportunities (Premkumar 2000, Gosain et al. 2004). As an example, RosettaNet user ST Micro-Electronics found that in the process of implementing the RosettaNet PIPs, the company and its customers were able to develop greater "intimacy," and this led to longer-term relationships. The company's IT director says, "We have become an integral part of our customers' internal planning systems and view this as

a distinct competitive advantage" (Peleg 2004). Thus, the use of SEBIs can reinforce cooperative motivations. Consequently, it is more likely that partners will more easily provide each other with information that they otherwise would not.

In addition, with SEBIs the flow of information can be largely automated. Therefore, information can be exchanged between supply chain partners without the need for extensive clarification or need to convey definitions or constraints. The breadth and quality of information exchange are also likely to increase with the use of standards. In this manner, SEBIs can be construed as a digital option creation mechanism that increases the richness of the information available to an enterprise from its partners (Overby et al. 2006).

The use of SEBIs to exchange information with a supply chain partner can also be construed as a means for an enterprise to build "identification" with a collective. After all, the partner enterprise may already be involved in exchanges with other enterprises using SEBIs. Standards also create spillovers and network externalities that benefit the collective. Identifying with the collective allows an enterprise to recognize the opportunity for information exchange and also to ascribe greater value to the information. Further, by creating network effects, SEBIs increase the range of information that may be accessed (i.e., through the partners of an enterprise's partners). In essence, when partners use SEBIs, they can integrate diverse knowledge across their supply chain partnerships.

To summarize, the use of SEBIs enables boundary-spanning mechanisms that allow for CIE between supply chain partners. In turn, CIE with partners allows enterprises to create knowledge by integrating information from diverse partners, and to represent differences and dependencies in knowledge domains (Carlile 2004, Levina 2005, Kellogg et al. 2006) required to mutually adapt to each other. Therefore, we hypothesize a *mediated* impact of the use of SEBIs:

**HYPOTHESIS 2.** *The use of SEBIs positively impacts MA and adaptive knowledge creation in supply chains indirectly by enabling CIE between partners.*

Malhotra et al. (2005) have proposed that the use of SEBIs as a boundary mechanism has an impact on structuring and information exchange capacity



of interorganizational partnerships. Standard interfaces can be seen as imposing design rules (Brusoni and Prencipe 2006) that assign functions to enterprises, identify operating principles, and set specifications that determine how organizations coevolve. Standards provide codified specifications that prescribe rules of engagement among components of a system (Garud and Kumaraswamy 1995). The use of interorganizational standards requires enterprises to first map and understand their end-to-end processes, as well as become aware of their dependencies with respect to their partner enterprises.

Further, the use of SEBIs requires partners to expend resources up front to ensure that their internal systems and processes are adjusted to leverage and enable interorganizational linkages. As an example, in its RosettaNet implementation, the ST Microelectronics implementation team devoted approximately four months to defining the required processes and how they were to be supported by technology, standards, infrastructure, and additional planning applications (Peleg 2004). The team then defined all the collaborative forecasting standard interfaces (PIPs) it wanted to use, as well as the relevant business-to-business (B2B) applications. This level of effort signals a long-term commitment to partnership and creation of “common-at-stake” (Carlile 2002, 2004). Consequently, SEBIs can lead to a greater propensity of partners to engage in MA.

Cognitively, SEBIs allow enterprises to build capacity to exchange information with partners and assimilate the exchanged information to create new knowledge. SEBIs can influence the absorptive capacity of the enterprises engaged in information exchange (Malhotra et al. 2005). The use of standards allows enterprises to acquire information from partners and assimilate it without unique translation and interpretation requirements. Also, by automating the flow of routine transaction information, the use of SEBIs allows the human actors in organizations to redirect their cognitive resources toward transforming and exploiting the collaborative information exchanged with partners. The enhanced absorptive capacity of enterprises involved in exchange enables them to create knowledge that enables the development of dynamic capabilities required to adapt to their environment (Zahra and George 2002). Based on

our discussion of cognitive and structural impact of use of SEBIs, we hypothesize:

**HYPOTHESIS 3.** *The use of SEBIs has a direct positive impact on MA and adaptive knowledge creation in supply chains.*

#### 2.4. Control Variables

Adaptive interaction patterns in business partnerships are likely to be influenced by the development of cooperative norms between interacting entities. “Cooperative norms reflect expectations the two exchanging parties have about working together to achieve mutual and individual goals jointly” (Cannon and Perreault 1999, p. 443). Cooperative norms assure that “relationship atmosphere is available to shape perceptions of unfolding events and so the very nature of the ongoing interaction processes are forever forming a dynamic and ever new business relationship” (Medlin 2004, p. 190). Therefore, in this research, we want to study the impact of SEBIs on information exchange and adaptive patterns of supply chain partnerships above and beyond that of cooperative norms. In addition, we also control for relationship time of supply chain partnerships. Relationship time has been argued to be an important determinant of the evolution of focus of partnerships, from economic exchange interactions to adaptation interactions (Medlin 2004).

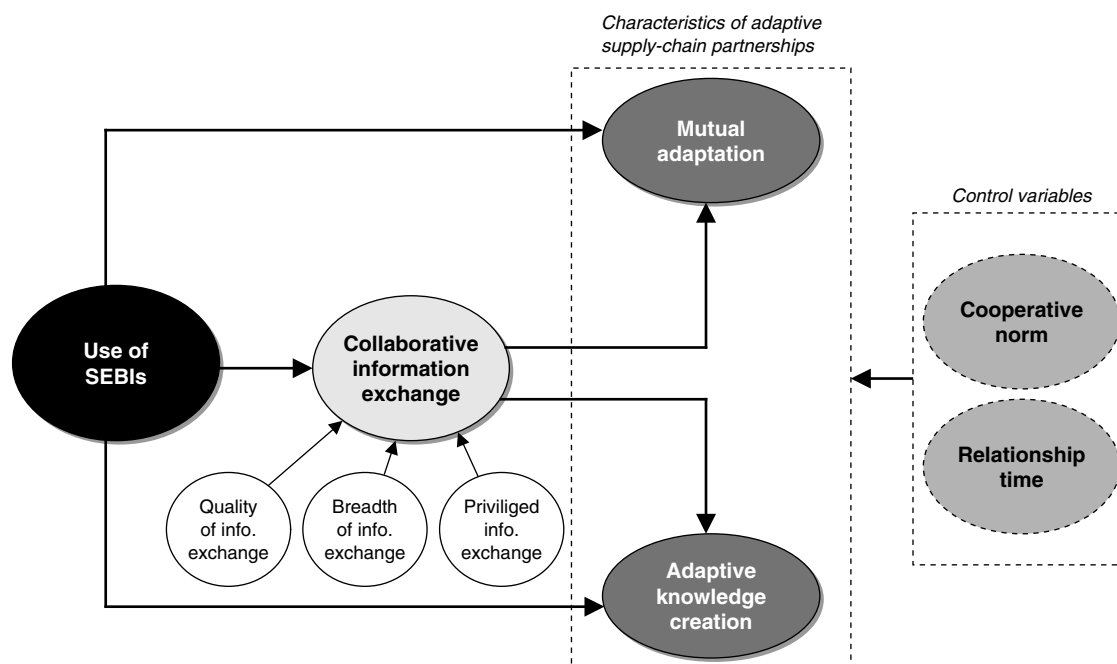
Figure 1 presents the research model around which the four hypotheses have been derived. In the next section, we describe the research methodology and field context used to test these hypotheses.

### 3. Research Methodology and Field Context

#### 3.1. Field Context and Data Collection

This research study was conducted in the context of the RosettaNet B2B initiative. RosettaNet ([www.rosettanet.org](http://www.rosettanet.org)) is a consortium of major IT, electronic component, semiconductor manufacturing, telecommunications equipment, and logistics enterprises working to create and implement industrywide, open e-business process standards for supply chain collaboration. The study builds on the authors’ two-year involvement with the RosettaNet Consortium. In the

Figure 1 Research Model



preliminary stage, we conducted 1- to 1.5-hour in-person and telephone interviews with 35 key executives (purchasing managers, customer relationship managers, supply chain managers, IT managers, and distribution managers) in 16 enterprises in the IT industry demand-side supply chain (seven hardware manufacturers/software publishers, one logistics provider, four wholesale distributors, and four retailers). These interviews helped us operationalize key constructs and further ground our theoretical arguments. The main data collection was based on a multiple-section survey questionnaire that was pretested and refined for clarity with supply chain managers at a major computer manufacturer (not part of our sample) and experts at a consulting enterprise.

Representatives of each enterprise on the RosettaNet board (executive champions) helped us identify their supply chain partners (restricted to three supply chain tiers—manufacturers, distributors, and retailers). This resulted in identifying 91 partnerships (focal enterprise with supply chain partner). The RosettaNet champions at each enterprise were mailed surveys for each of their partnerships. They were asked to drill down within their enterprise and find

the specific executive (“key informant”) responsible for day-to-day functioning of the partnership under investigation. The “key informant” (one per supply chain relationship) assigned various sections of the survey to be completed by managers most likely to provide accurate responses for a line of questioning. For instance, IT-related questions were completed by the IT manager, marketing issues related questions were filled by the managers in that area, and so on. For questions that would require a convergent view from multiple areas in the enterprise, the key informant was asked to hold a meeting to fill in those questions. Finally, the section that measured MA and adaptive knowledge creation in supply chain partnerships was completed directly by the key informant.

The completed surveys were collected and returned to us by the RosettaNet champion at each enterprise. We received responses from 13 enterprises that covered 41 of 91 pairs identified in the earlier phase. Each key informant in our sample was distinct and was responsible for responses for a single relationship only. Although we had desired a dyadic perspective (both enterprises engaged in a partnership responding to the survey), the difficulties in data collection

led us to focus on obtaining at least a one-sided perspective of each relationship.

A concern with this approach was that one-sided responses for supply chain partnerships could lead to some biases. A few checks and balances prevented this from being a severe limitation. We picked the specific partnerships that a particular enterprise would report on, rather than leaving it to the respondents to choose. This ensured that partnerships involving all major players (large companies) in the IT industry were covered through the response of one of their partners.

Our second concern was that a particular tier of the supply chain (manufacturer, distributor, or retailer) might wield greater power or market-making influence. Our initial interviews suggested that, in terms of day-to-day transactions, distributors in the IT supply chain had significant influence (because there were only five major players at this tier while there were several hundred major players in the manufacturer and retailer tiers). Hence, we ensured that we received

a perspective on each of the distributors in our sample (five in total) from either a manufacturer or a retailer. Additionally, we also made sure that each of the distributors provided a perspective on a relationship with either a manufacturer or a retailer. This was done to get complete coverage of the distributor tier in the supply chain.

After the data collection, we conducted a preliminary analysis to see if the data on partnerships that involved distributors was systematically different from that for other tiers (manufacturer-distributor and retailer-distributor compared with manufacturer-retailer). No such biases were evident from this analysis (i.e., there were no significant differences in means of the two types of relationship dyads).

### 3.2. Scale Development

The items used to operationalize each of the constructs in this study are provided in Appendix A. The sources of items for each of the scales are shown in Table 1.

**Table 1** Construct Definitions and Scale Development

Research construct	Definition	Origin of item scales
Characteristics of adaptive supply chain partnerships		
<i>MA</i>	The extent to which supply chain partners adjust their process and procedural and structural parameters to suit each other's needs and requirements	• Zaheer and Venkatraman (1994); Masten et al. (1991)
<i>Adaptive knowledge creation</i>	An enterprise's ability to leverage the knowledge resources of its partner to create the knowledge required to adapt to market environment	• Cooper (1979); Dougherty (1990) • Field interviews
CIE		
<i>Breadth of information exchange</i>	The exchange of information covering diverse areas related to interlinked business activities between an enterprise and its supply chain partner	• Field interviews with IT industry supply chain executives
<i>Quality of information exchange</i>	The timeliness, accuracy, relevance, and value of information exchanged between an enterprise and its supply chain partner	• Miller (1996)
<i>Privileged communication</i>	The exchange of confidential and exclusive information between an enterprise and its supply chain partners that provides the enterprise a unique perspective	• Heide and Miner (1992); Heide and John (1992) • Interviews and survey pre test
Facilitating mechanism		
<i>SEBIs</i>	The use of common specifications or formats (similar to those used with other partners) for the exchange of information and linking of processes at the interface between an enterprise and its supply chain partner	• Conceptualization based on RosettaNet initiatives
Control variables		
<i>Cooperative norms</i>	Expectations that supply chain partners have about working together to achieve and mutual and individual goals jointly	• Noordweir et al. (1990); Heide and Miner (1992)
<i>Relationship time</i>	The duration of the partnership between two enterprises in the supply chain	• Single item time measure (in months)

## 4. Analysis and Results

### 4.1. Measurement Validation

We used PLS Graph 3.0 for data analysis. PLS has an advantage over other structural modeling (SEM) methodologies in that it does not require distributions be normal or known (Joreskog and Wold 1982). Other structural estimation techniques like LISREL assume multivariate normal distribution or Wishart distribution, but PLS takes any distribution that is manifest though measurement and calculates the best set of predictive weights through a series of iterations. Another advantage of using PLS is that it has less stringent sample size requirements. Techniques such as LISREL use chi-square estimates for “goodness-of-fit” indicators. Unfortunately, chi-square estimates are extremely sensitive to sample size. The fit indices in PLS are descriptive statistics and indicate only the amount of variance accounted for in the model by the specified relationships.

Our next choice was whether the constructs would be modeled as reflective or formative. In making this choice, we followed the guidelines laid out by Jarvis et al. (2003). Constructs should be modeled as formative under the following conditions: (1) indicators are viewed as the defining characteristic of the construct, (2) changes in the indicators cause a change in the construct (and not vice versa), (3) indicators do not need to necessarily covary, (4) indicators are not necessarily interchangeable, and (5) indicators can be drawn from different nomological network (Jarvis et al. 2003, Patnayakuni et al. 2006). Based on these criteria, all the constructs in this study were modeled as formative constructs. Specifically, we used index scores of associated items to establish a measure for each formative construct. We had two choices to compute the index score—factor scores or mean value of items. Although, formative constructs are not required to exhibit internal consistency (Jarvis et al. 2003, Rai et al. 2006, Petter et al. 2007), the items were strongly correlated. Therefore, we chose the mean value to compute the index, which would naturally correlate highly with factor scores or other alternate weighting schemes for the items (Rozeboom 1979). Moreover, Hair et al. (1987) recommend the use of unit mean scores for replicability and ease of interpretation.

Similarly, breadth of information exchange (CIE 1), quality of information exchange (CIE 2), and privileged information exchange (CIE 3) were modeled as formative constructs. CIE was modeled as a formative construct comprised of three indicators: CIE 1, CIE 2, and CIE 3. The index scores for these three indicators were also derived based on the unit means of associated items (see Appendix A for items).

We began our data analysis by assessing the measurement properties of constructs. We conducted a pseudoconfirmatory factor analysis (as PLS does not provide cross loading of items on constructs other than those they are hypothesized to load) following the procedure outlined by Karahanna et al. (1999) and Patnayakuni et al. (2006). A mean factor score for each construct was computed from the items that were hypothesized to reflect the construct. Then all the items were correlated with each of the constructs. An indicator’s correlation with its hypothesized construct can be construed as “loading,” while its correlation with other constructs is “cross-loading.” Each of the items exhibits a higher correlation with its own construct than other constructs providing evidence for discriminant validity (Table 2). To further test for discriminant validity of our constructs, we examined the average variance extracted (AVE) for each construct and compared it with correlations between constructs (Fornell and Larcker 1981). As can be seen from

**Table 2** Item to Own Construct Correlation vs. Correlations with Other Constructs

Construct	Item	AKC	MA	STD	CIE	CN
Adaptive knowledge creation	AKC1	<b>0.82</b>	0.22	0.25	0.13	0.09
	AKC2	<b>0.68</b>	0.20	0.21	0.23	0.32
	AKC3	<b>0.84</b>	0.29	0.19	0.07	0.05
	AKC4	<b>0.78</b>	0.35	0.03	0.16	0.18
Mutual adaptation	MA1	0.26	<b>0.80</b>	0.33	0.18	0.04
	MA2	0.45	<b>0.91</b>	0.36	0.19	0.10
	MA3	0.13	<b>0.81</b>	0.37	0.01	0.33
Use of standard electronic business interfaces	STD1	0.16	0.40	<b>0.85</b>	0.21	0.21
	STD2	0.20	0.41	<b>0.93</b>	0.34	0.41
	STD3	0.20	0.28	<b>0.84</b>	0.20	0.37
Collaborative information exchange	CIE1*	0.27	0.13	0.25	<b>0.91</b>	0.13
	CIE2*	0.06	0.08	0.06	<b>0.69</b>	0.02
	CIE3*	0.09	0.14	0.36	<b>0.83</b>	0.11
Cooperative norm	CN1	0.14	0.16	0.24	0.06	<b>0.87</b>
	CN2	0.18	0.10	0.33	0.12	<b>0.86</b>
	CN3	0.18	0.21	0.42	0.20	<b>0.89</b>

\*Index computed as mean scores of associated items.



**Table 3** Measurement Properties of Constructs

Construct	Mean (SD)	1	2	3	4	5
1. Adaptive knowledge creation	4.27 (0.98)	0.77				
2. Mutual adaptation	3.91 (1.93)	0.33	0.84			
3. Use of standard electronic business interfaces	5.86 (1.62)	0.21	0.42	0.87		
4. Collaborative information exchange	5.01 (1.08)	0.25	0.15	0.31	0.80	
5. Cooperative norm	4.65 (1.12)	0.24	0.17	0.40	0.13	0.87

Note. Square root of AVE is shown along the diagonal.

Table 3, the AVE for each construct was higher than the constructs' correlation with other constructs as required for validating discriminant validity (Barclay et al. 1995). Table 3 also provides the mean and standard deviation values for all constructs.

#### 4.2. Common Method Bias Assessment

We tried to minimize the concern of common method bias by requiring the RosettaNet champions at each enterprise to drill down within their enterprise and find the executive ("key informant") responsible for the day-to-day functioning of the partnership under investigation (a different key informant for each relationship if multiple surveys were filled by a company). The key informant then assigned various sections of the survey to be completed by managers who they felt were most likely to provide accurate responses for a line of questioning.

So, in effect, different respondents were assigned to fill out different portions of our questionnaire. However, there was still some concern about the possibility that a single respondent may have completed the whole survey. To allay such concern, we conducted the Harmon's one-factor test. An exploratory factor analysis revealed a five-factor structure (Eigen value > 1) where all items did not load on the first factor and the first factor did not explain most of the variance in the data (~40% of the overall 76% variance explained). Therefore, the concern about common method bias in the data collected does not seem to be an issue. Further, not all the hypothesized paths were significant in the model, and the significant paths vary in their level of significance.

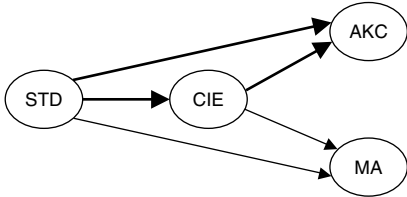
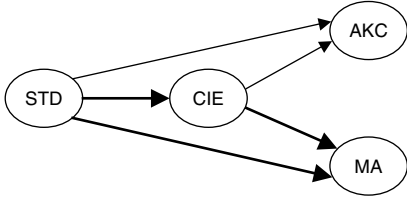
Therefore, the common method bias seems to be even less of a concern (Patnayakuni et al. 2006).

#### 4.3. Mediation Analysis

Our research model (Figure 1) proposes mediated impacts. Therefore, we followed the process outlined by Patnayakuni et al. (2006) and Subramani (2004) to test for mediation effects. We started out by comparing our research model, which proposes a direct effect and mediated effect of the use of standards, against a competing model that proposes full mediation (i.e., the effect of the use of SEBIs is fully mediated through CIE). The aim of such analysis is to statistically test whether the direct effect of the independent variables (IVs) explains additional variance in the dependent variable (DV) above and beyond the mediated effects through the mediating variable (MV). The proposed full model (direct and mediated effects—partial mediation) can be compared against the nested model (full mediation—mediated effects only) statistically using PLS results (Patnayakuni et al. 2006, Chin et al. 2003, Subramani 2004). As can be seen in Table 4, the  $R^2$  for adaptive knowledge creation ( $DV_1$ ) and MA ( $DV_2$ ) in the partially mediated models (models that include direct effects of use of standard interfaces) were 0.245 and 0.287, respectively, compared with  $R^2$  of 0.067 and 0.199 in the alternate nested (fully mediated) models. This differential effect in partial and complete mediation can be further investigated by a procedure similar to stepwise regression (Chin et al. 2003, Patnayakuni et al. 2006). A pseudo- $F$  statistic can be calculated by using the difference in  $R^2$  between the full model and the nested model.<sup>3</sup> The  $f^2$  statistic (calculated based on the difference in  $R^2$  between full and nested model) for the two dependent variables ( $DV_1$  and  $DV_2$ ), with respect to use of SEBIs (direct paths) is 0.06 and 0.304. Therefore, the pseudo- $F$  statistic is 2.07 (not significant at 0.05 level) and 10.34 (significant at 0.05 level). This analysis suggests that the additional direct path from the use of SEBIs (STD) to MA explains additional variance and adds significantly to the explanatory power of the model. However, there is a lack of evidence supporting a direct relationship

<sup>3</sup>  $F = f^2 * (n - k - 1)$ , with 1,  $(n - k)$  degrees of freedom.  $n$  = sample size,  $k$  = number of constructs in the model, and  $f^2 = (R^2 \text{ partial mediation} - R^2 \text{ full mediation}) / (1 - R^2 \text{ partial mediation})$ .

**Table 4** Test for Mediation—Full vs. Nested Model Analysis

Direct path	Graphic model	$R^2$ full model	$R^2$ nested model	$f^2$ value	Pseudo- $F(1, 35)$
STD $\rightarrow$ AKC ( $0.235^\beta$ , $t = 1.188$ )		0.245	0.199	0.06	2.07
STD $\rightarrow$ MA ( $0.518^\beta$ , $t = 3.642$ )		0.287	0.07	0.304	10.34*

\* Significant at  $p < 0.05$  level.

between the use of SEBIs (STD) and adaptive knowledge creation (AKC). In other words, there is a direct effect of use of SEBIs on MA, and there is also an indirect effect mediated through collaborative information exchange. On the other hand, the effect of the use of SEBIs on AKC is fully mediated through collaborative information exchange (CIE).

Further, we also assessed the mediation effect of CIE on the two DVs (AKC and MA). To do this, we used the path coefficients and standard errors between the use of SEBIs and the MV (CIE) and between CIE and the DVs obtained from the PLS (Patnayakuni et al. 2006, Hoyle and Kenney 1999, Subramani 2004). The magnitude of mediation is the product of path coefficients between the IV and MV and between MV and DVs. The magnitude of the two mediation effects is 0.103 (STD – CIE – AKC) and 0.087 (STD – CIE – MA). The z-statistic<sup>4</sup> for the two paths is 2.06 and 1.98 (significant at the  $p < 0.05$  level).

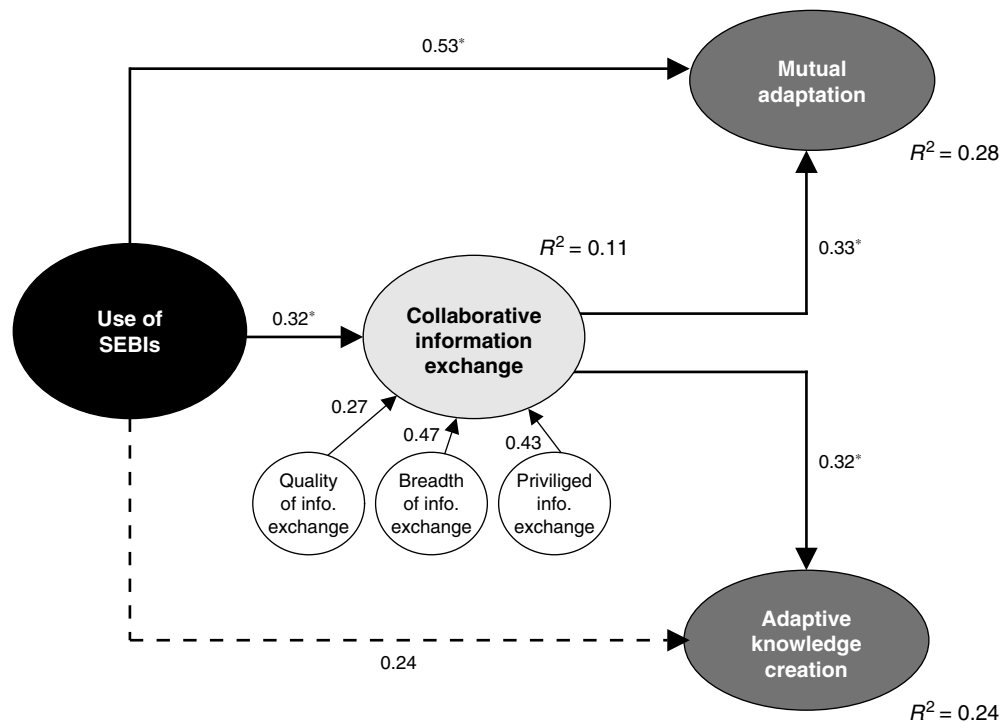
<sup>4</sup> The z-score is calculated using an approximation for the standard error of the mediated path. The approximated standard error is computed using the formula  $\sqrt{p_1^2 s_2^2 + p_2^2 s_1^2 + s_1^2 s_2^2}$ , where  $p_1$  is the path coefficient of the path from IV to MV,  $p_2$  is the path coefficient from MV to the DV, and  $s_1$ ,  $s_2$  are the corresponding standard deviations.

#### 4.4. Structural Model

The final results of the PLS analysis are shown in Figure 2. We evaluated the structural model based on the  $R^2$  values and structural paths for each of the endogenous constructs. As can be seen from Figure 2, the model explains a substantial amount of variance in the DVs: MA ( $R^2 = 0.28$ ) and AKC ( $R^2 = 0.24$ ) between supply chain partners. The significance of the paths was obtained through the bootstrapping procedure in PLS.

The results (Figure 2) provide support for most of the hypothesized paths in the research model shown in Figure 1. There is support for Hypothesis 1, as the paths from CIE to MA ( $\beta = 0.33$ ,  $p < 0.05$ ) and AKC ( $\beta = 0.32$ ,  $p < 0.05$ ) are statistically significant. The use of SEBIs has a positive effect on CIE ( $\beta = 0.32$ ,  $p < 0.05$ ), providing support of Hypothesis 2. Hypothesis 3 is partially supported, as the use of SEBIs has a significant direct effect on MA ( $\beta = 0.53$ ,  $p < 0.05$ ) but does not have a statistically significant direct effect on AKC ( $\beta = 0.24$ ). As discussed earlier, the MA shows that the effect of the use of SEBIs on mutual adaptation between supply chain partners is partially mediated and the effect on AKC is fully mediated through CIE (i.e., there is no direct effect). The paths from the control variables to the DVs were not significant.

Figure 2 Results of Path Analysis



Notes. All solid paths shown are significant at the  $p < 0.05$  level. The dotted path is not significant at the  $p < 0.05$  level. \* Significant at  $p < 0.05$  level.

## 5. Implications of the Study

Our results demonstrate that the use of SEBIs can indeed influence adaptiveness of supply chain partnerships. Hypotheses 1 and 2 are supported, while Hypothesis 3 is partially supported. CIE between supply chain partners mediates the effect of the use of SEBIs on adaptiveness of supply chain partnerships. The results also show that the use of SEBIs has both a direct and indirect association with MA and an indirect association with AKC (mediated through CIE). In combination, these results have several implications for understanding adaptive supply chain partnerships in digitally enabled extended enterprises and the design of SEBIs.

### 5.1. Understanding Adaptive Supply Chain Partnerships Through the Use of SEBIs

The study has identified and articulated two different aspects of adaptive supply chain partnerships in the digitally enabled extended enterprise. MA requires focusing attention on connecting two disparate enterprises using flexible structuring mechanisms. On the

other hand, AKC emphasizes mindfulness of learning-related goals in the relationship. We have uncovered two unexpected findings in explaining the two salient characteristics of adaptive supply chain partnerships.

First, although we expected SEBIs to have a direct effect on both dimensions, we found that attaining the learning-related outcome is contingent on CIE in the extended enterprise. Broad-ranging, privileged (to a large extent), and high-quality (to a lesser extent) information exchange with the supply chain partners is the basis for deeper understanding about the market environments by an enterprise. The more types of information (range) are exchanged, the more complete picture about the market environment emerges for the receiving partner. Similarly, privileged information may be more trusted and may require less cognitive effort to digest to understand the market dynamic. From the result, it also seems that range and specific nature of information exchange is more valuable than the quality of information.

The result also suggests that when the use of SEBIs results in CIE, a common understanding is established that can then be used as a springboard for fur-

ther AKC. Also, without use of standard interfaces, the partners may be favorably disposed to exchange broader-range and privileged information with each other (exhibit bonding), but they face obstacles in connecting to others to draw on each others' knowledge bases (lack bridging). Bridging and bonding are inextricably intertwined in their effects on adaptiveness of supply chain partnerships in the digitally enabled extended enterprise when SEBIs are involved.

### 5.2. Bridging and Bonding Through SEBIs in the Digitally Enabled Extended Enterprise

There are two opposing views on how an organization's learning and adaptation are influenced by the network in which it is embedded (Kraatz 1998): the strength of weak ties and the strength of strong ties. The literature on strength of weak ties holds the view that weakly tied entities in a network are more likely to have nonoverlapping knowledge bases that provide distinctive value (Burt 1982; Granovetter 1973, 1982). Based on the logic of requisite variety, the larger the variety of ties the enterprise has, the better off it is in terms of learning and adaptation. The use of SEBIs by enterprises in supply chains makes it easy to link to new partners when the need arises. In this way, the use of SEBIs by enterprises will help them capitalize on the strength of weak ties.

However, at the same time, the literature on the strength of strong ties suggests that strong ties enable better adaptation (Kraatz 1998). Such ties exhibit high interactivity between enterprises and high interdependence (Granovetter 1982, Krackhardt 1992). Although this view does not refute the claim that stronger ties may reduce the number of information sources, it does however point to several benefits of strong ties that overcome this drawback (Kraatz 1998). Strong ties encourage the creation of high-capacity information links between enterprises and allows them to share insights and experiences with each other (Kraatz 1998).

Our findings suggest that the use of SEBIs between partners lets them leverage strong ties by enabling high-capacity (broader-range and more privileged) information links. The shared understanding created through the SEBIs also leads to better understanding of the specific information needs of partners. At the same time, the very act of adopting and using

standard (but flexible) interfaces builds a strong bond between partners, motivating their MA. The use of SEBIs lets an enterprise's partner know that the enterprise is acting in the partner's best interest and that the partner is not locked in to a partnership by adopting and using SEBIs. Thus, standardized (yet flexible) interfaces being developed and promoted by institutions such as RosettaNet reconcile the strengths of weak and strong ties. Therefore, the use of SEBIs can facilitate bridging and bonding *without binding* in the digitally enabled extended enterprise. The use of SEBIs acts as a bridging mechanism and allows partners to bring perspectives from different partnerships that enrich the CIE between partners. Thus, the use of SEBIs is a dual-purpose mechanism of enabling network effects in transactional exchange, while it may also signal the willingness to collaborate and adapt to the needs of the partner.

### 5.3. Designing and Effectively Deploying SEBIs

Our study suggests the importance of nurturing the CIE to develop an understanding of how to adapt to change. This requires an investment in building awareness of how competence can be procured from partners (through sharing of broad-ranging and privileged information) and blended with organizational expertise. It also requires a foundational level of knowledge to be able to seek out and evaluate partner skills and the absorptive capacity to assimilate it (Cohen and Levinthal 1990, Malhotra et al. 2005). The role of information systems in capturing and disseminating knowledge and supporting its interpretation is important, especially when a broad-range of information is shared with partners. Such knowledge-creation focused systems need to be designed to flexibly represent knowledge and to allow employees to identify their assumptions about partners and envision the impact of changes in the value network in which their enterprise resides (Malhotra et al. 2005).

In addition to these prerequisites for designing and effectively deploying SEBIs in the context of the digitally enabled extended enterprise, the study has implications for the tightness of specification for the functional requirements of SEBIs. The use of standards also provides structure for information exchanges to be coded and provides a grammar for information to be expressed. To sustain broad-ranging



and more privileged information exchange, standard specifications should allow for some degree of freedom while enforcing templates. Thus, generative templates could consist of structural specifications of information exchange and process sequences, but leave the specific data elements and activities to be selected from an admissible set of contingent possibilities. For instance, the high-level specifications might lay out partly specified documents to be exchanged to complete a purchase process with a supplier. The detailed schema information for a document for a particular relationship could be part of a supplier-specific document type definition, which would enable the documents to be completely specified. This extensible and quasi-open specification of SEBIs is a critical element to bridging and bonding without binding in the digitally enabled extended enterprise context.

#### 5.4. Limitations and Unanswered Questions

Finally, we have to acknowledge some limitations of our study. While focusing on partnerships as a unit of analysis, we did not directly account for network effects, such as the effect of other partnerships on the focal partnership. In a network, partnerships are molded and influenced based on other partnerships. Very often political angles are at play in such networks, which further impacts various partnerships. It would have been ideal for us to either control for network effects or to fully take them into account and not on a partial basis. Unfortunately, the way the data were collected and analyzed prevented us from doing so.

This research has to be extended to study the impact of the network on the whole within which diverse supply chains exist. Such studies can use network analysis methodologies to answer the following questions: Are enterprises that exchange information with several diverse players in a supply chain better able to exchange and assimilate richer information? Does an enterprise's diversified portfolio of partnerships impact the nature of information he exchanges with his partners? How are relationship portfolios and network benefits impacted by the use of SEBIs?

By obtaining data on all possible partnerships, the findings from dyadic analysis can be extended to the network as a whole. Future research can also validate our findings in other industries with larger sample sizes. It is possible that some of the relationships

that were found to be not statistically significant were that way because of the limited sample size used in this study. It is also important to clarify the implications of the manner in which we conceptualize and measure the use of SEBIs. We only treat SEBIs as an emergent phenomena and measure variance in the extent to which enterprise dyads conform or deviate from the specifications for their other partnerships. This does not shed light on the process by which such a state was accomplished. We also have not distinguished between an explicit adoption of formal standards or an informal structuring that occurs over time giving rise to a SEBI. Future research can use a process methodology to better understand the implications of both these pathways.

Finally, we acknowledge that there are several other significant factors that can impact CIE between partners. Future research should focus on exploring the political (power asymmetries in partnerships), social (human-to-human interactions), and technological (how long SEBIs have been used by partners) impact on CIE.

## 6. Conclusion

While there has been considerable research on understanding the drivers of dynamic value creation at the enterprise level (e.g., Teece et al. 1997, Eisenhardt and Martin 2000, King and Tucci 2002), there has not been as much examination of the capabilities and processes needed to drive value creation in inter-enterprise arrangements (Duysters and Heimeriks 2002), and even less so in the case of the digitally enabled extended enterprise. This study has attempted to shift the focus toward partnerships that a digitally enabled extended enterprise is embedded in and how they can be enabled to regenerate competitive advantage under conditions of rapid change. In their study of product innovation, Brown and Eisenhardt found that enterprises with successful product portfolios were those that blended limited structure with extensive communication. They found rhythmic transitions from one project to another captured by the following analogy: "Successful managers are like 'Tarzan'<sup>5</sup>—they swing on the current vine, looking for the next, and making the switch between the two" (1997, p. 7).

<sup>5</sup> Tarzan is a fictional literary character who successfully coped with the perils and constraints of the complex jungle environment.

Our study advances similar ideas for digitally enabled extended enterprises in jointly transitioning through changes in business conditions. We show that SEBIs can provide the structure at enterprise boundaries to allow partner-related knowledge to be represented and transformed. Enterprises may then proceed from this external specification and design their internal processes. This ensures that that change proceeds “outside-in,” triggered by changes at the interfaces of enterprises in the value network, resulting in conditions where enterprises are only partially embedded in their value networks. We have shown that the use of these process and information exchange interfaces positively impacts MA (a coordination goal) as well as AKC (a learning goal). The use of second-generation SEBIs can indeed be leveraged to build adaptive supply chain partnerships in the context of digitally enabled extended enterprises.

As new forms and generations of SEBIs emerge with richer extensibilities that are enabled through new architectures (such as service-oriented architectures, real-time “publish and subscribe” architectures, and multimedia instant messaging protocols), we anticipate that the use of SEBIs will further enhance adaptive supply chain partnerships. Tarzan will have even more ways to swing on his vines and bridge and bond with the rest of the jungle.

### Acknowledgments

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### Appendix A. Construct Scales

#### Mutual Adaptation

In your relationship with ⟨partner company⟩ what percentage of...

1. ...products and services are customized to suit each other's needs? (MA1)
2. ...inventory procedures were changed to suit each other's needs? (MA2)
3. ...delivery procedures were changed to suit each other's needs? (MA3)

[1 = None of Them to 7 = All of Them]

#### Adaptive Knowledge Creation

Working with ⟨partner company⟩ has...

1. ...helped you better understand the capabilities and intentions of your competitors. (AKC1)
2. ...helped you better understand the evolving roles of channel players. (AKC2)
3. ...helped you learn how to perform new (additional) roles in the channel. (AKC3)
4. ...led your company to analyze and redesign processes linked to channel partners to improve the performance of the channel on the whole. (AKC4)

[1 = Strongly Disagree to 7 = Strongly Agree]

#### Collaborative Information Exchange

##### Breadth of Information Exchange

1. Extent to which you exchange *details of upcoming product or service-related changes* with ⟨partner company⟩.
2. Extent to which you exchange *future plans such as promotion and marketing plans, long-term production plans, capital investments, and capacity utilization* with ⟨partner company⟩.
3. Extent to which you exchange information related to *market demand trends and forecasts* with ⟨partner company⟩.
4. Extent to which you exchange information on *demand shifts and changes in customer preferences* with ⟨partner company⟩.
5. Extent to which you exchange information related to *changes in supply chain structure*, such as addition or dropping of partner companies, merger, and alliances, with ⟨partner company⟩.
6. Extent to which you exchange *process information needed to support changes in product features or volumes* with ⟨partner company⟩.

[1 = Not At All to 7 = Very Frequently]

##### Quality of Information Exchange

How would you rate the information exchanged with ⟨partner company⟩ in terms of its...

1. ...relevancy to your business needs, compared with information exchanged with other similar partners?
2. ...value added to your business needs, compared with information exchanged with other similar partners?
3. ...timeliness, compared with information exchanged with other similar partners?
4. ...its completeness, compared with information exchanged with other similar partners?

[1 = Worse to 7 = Better]

##### Privileged Information Exchange

1. In our relationship with ⟨partner company⟩, we provide proprietary information if we feel it can help our business partner.
2. In our relationship with ⟨partner company⟩, we share confidential information if we feel it can help our business partner.

3. In our relationship with ⟨partner company⟩, we share information with each other that is not available from other sources.

4. In our relationship with ⟨partner company⟩, the information exchange helps us provide each other with a unique perspective that neither of us could have developed on our own.

[1 = Strongly Disagree to 7 = Strongly Agree]

#### Use of Standard Electronic Business Interfaces (STD)

1. Extent to which the business process interfaces with ⟨partner company⟩ are similar to the process interfaces linked with other channel partners—in terms of rules and procedures. (STD1)

2. Extent to which information exchanged (e.g., sales reporting, product information, product availability, inventory information, etc.) with ⟨partner company⟩ needs to be converted/translated to be interpreted by your company. (STD2)

3. Extent to which content of information exchanged (e.g., sales reporting, product information, product availability, inventory information, etc.) with ⟨partner company⟩ can be interpreted similar to information exchanged with other partners. (STD3)

[1 = Not At All to 7 = to a Large Extent]

#### Cooperative Norm

In our relationship with ⟨partner company⟩...

1. ...no matter who is at fault, problems are considered joint responsibilities. (CN1)

2. ...both sides are concerned about each other's profitability. (CN2)

3. ...both sides are willing to make cooperative changes. (CN3)

[1 = Strongly Disagree to 7 = Strongly Agree]

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