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An empirical study of the impact of e-business technologies on organizational collaboration and performance

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Abstract

The use of e-business technologies between supply chain organizations has been thematic in recent literature. Organizational collaboration, the foundation of supply chain management, has been enabled by the development and use of e-business technologies. Organizational collaboration and information sharing, in turn, are expected to improve organizational performance. We propose and test a model of the relationship between organizational use of e-business technologies, organizational collaboration, and performance, using empirical data. Our model differs from past studies in that collaboration is viewed as two unique constructs, differentiating between intra- and inter-organizational collaboration. Our findings show that use of e-business technologies impacts performance both directly and indirectly by promoting both measures of collaboration. Intra-firm collaboration is also found to have a direct impact on organizational performance. However, the impact of inter-organizational collaboration on performance is found to be only indirect, through the impact of intra-organizational collaboration. These findings reveal the complexity of organizational collaboration, underscore the importance for companies to promote internal collaboration, and invest in information technologies that facilitate it.

Keywords: e-Business technologies; Structural equation modeling; Intra-organizational collaboration; Inter-organizational collaboration; Supply chain management

1. Introduction

The growth of information technology (IT) has rapidly changed the face of business over the past decade. Supply chain management (SCM), founded on collaboration between supply chain partners (Narasimhan and Jayaram, 1998; Prahinski and Benton, 2004; Vakharia, 2002), has been especially impacted. IT has made possible the sharing of large amounts of information along the supply chain, including operations, logistics, and strategic planning data. This has enabled real-time collaboration and integration between supply chain partners, providing organizations with forward visibility, improving production planning, inventory management, and distribution. IT, which allows for the transmission and processing of information necessary for synchronous decision making, can be viewed as the backbone of the supply chain business structure (Kearns and Lederer, 2003; Grover and Malhotra, 1997). For this reason the literature often refers to IT as an essential enabler of SCM activities (Mabert and Venkataramanan, 1998).

Of all the information technologies, the Internet and the Web may have had the most profound impact on business integration and collaboration (Rabinovich et al.,

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2003). The Internet, Web, and web-based applications, termed here e-business technologies, have had a particularly significant impact on managerial practices due to their interoperability and open-standard settings for the transfer of data among organizations (Bailey and Rabinovich, 2001; Rabinovich et al., 2003). In fact, the Internet has surpassed information technologies such as electronic data interchange (EDI), a technology available for more than 20 years, in its information sharing capabilities and cost (Chopra et al., 2001).

Today almost all organizations are in the process of adopting some type of e-business technology to streamline SCM activities. For example, e-procurement has automated and streamlined many corporate purchasing processes (Sengupta, 2001); the Web is being used for collaborative processes such as CPFR (Steerman, 2003); and, in the auto industry, supplier firms are using Internet features such as e-mail and discussion forums to understand details of the automaker's requirements not completely conveyed in formal documentation (Takeishi, 2002).

Studies have found overall IT capability to be positively linked to organizational performance (Bharadwaj, 2000; Kearns and Lederer, 2003) and shown to have the potential of providing a significant competitive advantage to firms (Earl, 1993; Ives and Jarvenpaa, 1991; Kathuria et al., 1999). Similarly, organizational integration has been shown to have a positive impact on performance (Vickery et al., 2003; Stank et al., 2001). Less attention has been paid to the direct impact e-business technology use has on facilitating integration and impacting organizational performance.

The goal of this research is to extend knowledge on how use of e-business technologies impacts organizational collaboration, a form of integration (Stank et al., 2001), and organizational performance. Specifically, we propose and test a model of the relationship between organizational use of e-business technologies, organizational collaboration, and organizational performance. We focus on collaboration as the mediating variable between e-business technology use and performance given that it is considered a critical element of SCM and, as such, has received a great deal of attention in the literature (Frohlich and Westbrook, 2001; Narasimhan and Jayaram, 1998; Prahinski and Benton, 2004; Vakharia, 2002). Further, collaboration is directly enabled by IT use (Stank et al., 2001; Vickery et al., 2003), and understanding details of this mechanism is of high importance. Our model extends knowledge in this area by differentiating between intra- and inter-organizational collaboration, unlike past studies that look at collaboration as a composite of interactions and collaborative behaviors (Kahn and Mentzer, 1996; Stank et al., 2001; Vickery et al., 2003). This enables us to provide a finer grain perspective of collaboration and its relationship to e-business technology use and performance. The model and constructs used in our study are directly derived from the literature.

Our findings show that use of e-business technologies impacts performance both directly and indirectly, mediated by inter and intra-organizational collaboration. Most interestingly, inter-organizational collaboration is found to impact performance only indirectly, by impacting intra-organizational collaboration. These results have important implications for both managers and researchers as they provide insights into the mechanism of how e-business technology use impacts performance and the inherent complexity of collaboration.

2. Background

2.1. Integration, collaboration, and organizational performance

Supply chain management takes a systems view regarding all activities and functions that are needed to bring a product or service to market. The theoretical foundation for SCM can be traced back to Forrester's work on system dynamics (1961). This view recognizes that the value creation process extends beyond the boundaries of the organization, and involves integrated business processes among entities of the chain, such as suppliers, manufacturers, and customers (Stevens, 1989; Tan et al., 1998). The value creation process of the chain was further developed by Porter (1980, 1985) who advocates exploitation of "linkages" within a firm's value chain and between the value chains of its suppliers and customers. Exploitation of these "linkages" is expected to lead to superior performance (e.g. Tan et al., 1998; Frohlich and Westbrook, 2001) and promulgates the idea that individual organizations that comprise the supply chain must ultimately be managed as a single entity or one complete system. This requires integration, collaboration, and coordination across individual firm functions and throughout the supply chain.

Research consistently supports the idea that integration between firms improves firm performance (Stevens, 1989; Lee et al., 1997; Metters, 1997; Narasimhan and Jayaram, 1998; Lummus et al., 1998; Anderson and Katz, 1998; Hines et al., 1998; Johnson, 1999; Frohlich and Westbrook, 2001). Problems of nonintegration between firms have been well documented beginning with Forrester's (1961) seminal work (Lee and Billington, 1992; Hammel and Kopczak, 1993; Frohlich and Westbrook, 2001). Lack of coordination has been shown to create the classic magnification of demand up the supply chain, know as the bullwhip effect, resulting in alternating excess inventory and stock-outs (Lee and Billington, 1992). Having an integrated supply chain has been shown to provide a significant competitive advantage relative to both price and delivery (Lee and Billington, 1992).

Today's most successful manufacturers have tight coordination with their supply chain partners, enabling real-time information to travel immediately up and down the supply chain and well coordinated movement of inventories. The result are products that are delivered quickly and reliably when and where they are needed, high responsiveness to short lead times, the elimination of the bullwhip effect, and improved firm performance (Lee et al., 1997). Consider the recent collaborative relationship between Sears and Michelin using CPFR, which has resulted in a 25% reduction in inventories for both companies (Steerman, 2003). Similarly, General Motors' new collaborative relationship with its suppliers has reduced vehicle development cycle times from 4 years to 18 months (Gutman, 2003).

Although research consistently shows that integration improves firm performance, most of these studies have focused on integration from only one side of the supply chain and with the exclusion of separate consideration of intra-organizational integration. One exception is a study by Frohlich and Westbrook (2001) that looked at the impact of integration on differences in mean levels of performance, simultaneously considering upstream and downstream integration. Their study, however, did not examine the specific relationship between integration and performance. Another exception is Vickery et al. (2003) who looked at intra and inter-organizational integration, however, as one only construct comprised of both integration across functional areas and across firm boundaries. Little confirmatory evidence has been provided on simultaneous consideration of intra and inter-organizational integration on performance and their interaction with one another. Further, research usually measures integration as a composite of a series of interactions and collaborative behaviors (Kahn and Mentzer, 1996; Stank et al., 2001; Vickery et al., 2003), rather than providing a finer grain focus on specific dimensions of integration.

2.2. *e-Business technology and organizational collaboration*

The Internet and web-based technologies have significantly improved collaboration and integration among supply chain partners permitting strong customer and supplier integration for inventory planning, demand forecasting, order scheduling, and customer relationship management (Feeny, 2001). In a recent London School of Economics survey CEOs rated IT as the firm's top strategic tool, but asserted that the source of competitive advantage was not technology per se, but superior information sharing provided by these systems (Compass Group, 1998). Of all the information technologies, the emergence of the Internet may have had the greatest impact on information exchange between buyers and sellers to date (Rabinovich et al., 2003). Accessing real-time demand information and achieving inventory visibility was virtually impossible prior to the Internet, and relied on composites made from information accessed via telephones, faxes, and EDI. The Internet has now surpassed information technologies such as EDI in its information sharing capabilities and cost (Chopra et al., 2001). EDI permitted sharing of limited content with a few remote partners at a relatively high cost. Today, Internet enabled supply chains are powerful strategic weapons due to their unparalleled integration of information among partners and relatively low transaction cost.

The argument that e-business technologies promote supply chain integration is further supported by transaction cost economics. The premise of the literature in this area is that cooperation and coordination among firms is limited by the transaction costs of managing the interaction (Coase, 1937; Williamson, 1975; Stoeken, 2000). As transaction costs increase, market transaction efficiency decreases. These inefficiencies may result in higher market prices and promote vertical integration in the supply chain. IT has been shown to decrease transaction costs, comprised of coordination costs, that include direct costs of integrated decisions (Nooteboom, 1992), and transaction risk, which is the risk of being exploited in the relationship (Clemons and Row, 1992; Clemons et al., 1993). Transaction cost economics suggests that IT should promote organizational cooperation and collaboration given that it reduces transaction costs. The Internet and the Web may have a particularly strong impact due their interoperability, open standards, and low cost.

While Internet-enabled supply chains may be powerful strategic weapons in providing supply chain connectivity, there are still many unanswered questions about them in practice (Frohlich, 2002; Bowersox et al., 2000). Much of the research on the Internet has focused on the facilitation of consumer transactions and Internet retailers (Bakos, 1997; Brynjolfsson and Smith, 2000). Less attention has been paid to the unique mechanism of how use of the Internet and the Web impact organizational integration and collaboration.

SCM practices encompass a spectrum of activities, some internal and some external to the organization, all with the primary goal of creating value to the end-customer (Handfield and Nichols, 1999). This is accomplished through coordination of activities between linked firms, and should result in reduced costs due to the elimination of operational duplication and resource waste (Andraski, 1998; Stank et al., 2001). This requires engaging in collaboration that is both internal and external to the organization (Stank et al., 2001). The unique impact of e-business technologies on both internal and external collaboration has still been unexplored.

2.3. e-Business and organizational performance

The impact of IT on the organization as a whole has been studied at length (Davenport, 1993; Brynjolfsson and Hitt, 1996). This research has ranged from studying the alignment of specific IT applications with the organizational competitive priorities and alignment with strategic objectives (Kathuria et al., 1999; Kearns and Lederer, 2003) to comparisons of the effectiveness of specific IT applications (Raghunathan, 1999) and method of IT use (Subramani, 2004). In general, IT is shown to promote higher levels of organizational integration, expected to result in improved organizational performance (Vickery et al., 2003).

Research regarding the direct impact of IT on specific performance measures has resulted in inconsistent results, suggesting that a 'productivity paradox' exits (Lim et al., 2004; Sriram and Stump, 2004). Numerous explanations have been offered for this paradox, such as management's failure to leverage the full potential of IT (Dos Santos and Sussman, 2000), ineffective implementation (Stratopoulos and Dehning, 2000), poor measures of performance (Bharadwaj et al., 1999), and the presence of a time lag between IT investment and its actual impact on performance (Deveraj and Kohli, 2000; Rai et al., 1996). Researchers have also tried to explain the apparent paradox by drawing attention to the differences between the research traditions of the disciplines (e.g. economics, production, and strategy) from which the studies are derived (Sircar et al., 2000; Sriram and Stump, 2004).

Another view of IT's impact on performance is that IT improves firm performance indirectly by fostering inter-organizational relationships (Hammer and Mangurian, 1987). Wen et al. (1998) consider that the benefits of IT may be "qualitative, indirect, and diffuse" and suggest that IT may ultimately impact performance by influencing relational outcomes. For example, extranet IT investments made by Fujifilm in Canada allow the firm to provide a wider range of information to dealers and resellers and also enable the company's salespeople to build online relationships with these intermediaries (Gilbert, 2002). These studies suggest that it may be important to simultaneously consider a direct and indirect impact of e-business technology use in order to measure its full impact on organizational performance.

3. Conceptual model and research hypotheses

We propose a conceptual model, shown in Fig. 1, of the relationship between organizational use of e-business technologies (e.g. Internet, intranets, extranets, and web-based applications), intra- and inter-organizational collaboration, and organizational performance. The study of e-business technologies is different from the broader meaning of IT, which can be defined as technological capability used to acquire, process, and transmit information for more effective decision making, relative to competitive standards (Grover and Malhotra, 1997). Using this distinction, e-business is subsumed under the area of IT, with the former being the focus of this study. Our model shows use of e-business technologies as a factor influencing the organization's internal and external collaboration, two unique collaboration constructs. Intra-organizational collaboration is a construct defined as an affective, mutual shared process where two or more departments work together, have mutual understanding, have a common vision, share resources, and achieve collective goals (Schrage, 1990; Stank et al., 2001). Intra-organizational collaboration requires cross-functional planning, coordination, and sharing of integrated data bases. Inter-organizational collaboration is defined similarly to internal collaboration, with the exception that the focus of collaboration is between two or more organizations, rather than departments. Inter-organizational collaboration requires sharing of information across the full range of supply chain participants, as well as sharing of internal cross-functional processes (Schrage, 1990).

The relationship between e-business technologies and intra and inter-organizational collaboration has been assumed by past studies (Raghunathan, 1999), though it has not been directly tested. Studies have, however, tested the relationship between general IT use and other constructs that are related to collaboration (Mohr and Nevin, 1990), such as relationship commitment (Kent and Mentzer, 2003). For example, a study by

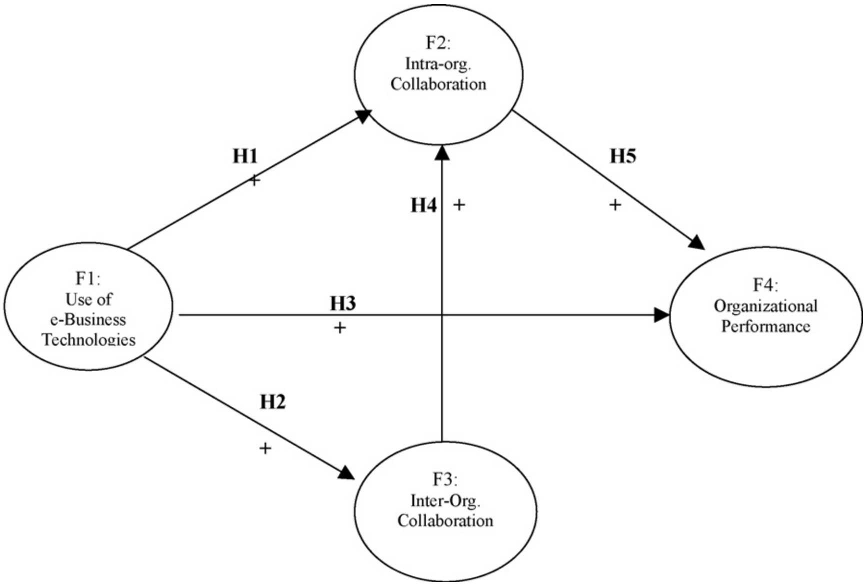

Fig. 1. Proposed conceptual model.

Kent and Mentzer (2003) found a strong and positive relationship between investment in information technologies and relationship commitment between channel partners. Other researchers have demonstrated that IT use can decrease coordination costs (Clemons and Row, 1992; Clemons et al., 1993), expected to bring about increased coordination (Vickery et al., 2003). These studies collectively support the development of our first two hypotheses that assume a positive impact of e-business technology use on both intra- and inter-organizational collaboration:

H1. Firm use of e-business technologies (EB) has a direct and positive impact on intra-organizational collaboration (IC-1).

H2. Firm use of e-business technologies (EB) has a direct and positive impact on inter-organizational collaboration (IC-2).

A review of the IT literature reveals mixed results with respect to the impact of IT on organizational financial performance (Hu and Plant, 2001). A study by Hitt and Brynjolfsson (1996) finds that the inconsistencies observed among various studies can be attributed to variations in methods and measures used in the analyses. Most recent studies, however, have found support for the direct impact of IT on financial performance (Bharadwaj, 2000; Kearns and Lederer, 2003; Santhanam and Hartono, 2003). Based on these studies we can expect use of e-business technologies to be significantly and positively related to organizational performance, which we define as success relative to specifically set business goals (Kearns and Lederer, 2003). This leads to our third hypothesis:

H3. Firm use of e-business technologies (EB) has a direct and positive impact on organizational performance (OP).

Our proposed model further proposes that inter-organizational collaboration directly impacts intra-organizational collaboration, which in turn directly impacts organizational performance. The relationship that we posit between intra- and inter-organizational collaboration in the current model is consistent with the latest studies (Stank et al., 2001; Subramani, 2004). Subramani (2004) argues that the collaboration and the association suppliers develop with buyers are in fact directly constrained by communication within the firm. In effect, internal communication serves to mediate buyer–supplier collaboration. Stank et al. (2001) also find external collaboration to directly influence internal collaboration. Similarly, a recent study of the impact of IT on supply chain collaboration (Vickery et al., 2003) assumes that collaboration *within* the organization and *between* organizations are equally subsumed under the construct of supply chain integration. The authors argue that the various internal functions comprising a company are essentially a part of the supply chain. Our model tests this relationship and leads to our next hypothesis:

H4. Inter-organizational collaboration (IC-2) has a direct and positive impact on intra-organizational collaboration (IC-1).

Finally, higher levels of coordination are expected to contribute to improved organizational performance. Vickery et al. (2003) provide empirical support for a link between integration and customer service performance. Their study finds a significant impact of supply chain integration on elements of customer service performance for firms in the auto industry. Similarly, Stank et al. (2001) find internal collaboration to positively impact firm performance. This leads us to our last hypothesis:

H5. Intra-organizational collaboration (IC-1) has a direct and positive impact on organizational performance (OP).

4. Research methodology

4.1. The sampling procedure

Data for this study were obtained from a survey of U.S. manufacturing firms. The survey instrument was initially pre-tested by six executives and five academics. The individuals were asked to review the questionnaire for readability and ambiguity (Dillman, 2000). Based on results of the pretest, minor changes were made to select questionnaire items, and the instrument was mailed to 2000 U.S. industrial companies.

As the information targeted was strategic in nature, the survey instrument was sent to the highest ranking officer of primarily large manufacturing companies with annual sales in excess of $4.5 billion. We requested that the questionnaire be completed with a focus on the Strategic Business Unit or SBU. Officers of companies with multiple business units were requested to select one, and to forward the questionnaire to the CEO of that unit. Therefore, the unit of analysis is the SBU. The decision to target high ranking officers is supported by a study by Phillips (1981) that finds high ranking informants to be more reliable sources of information than low ranking. The database was purchased with these criteria specified from American Business Lists. The typical respondent to the survey held the title of President, CEO, Vice President, or Director of Procurement and Purchasing, as shown in Table 1.

A variation of Dillman's total design method was used (Dillman, 2000) in order to ensure adequacy of response. The initial mailing included a cover letter and the survey instrument, with the latter designed to be merely folded and returned, with postage pre-paid. Reminder postcards were sent approximately 10 days following the initial mailing, followed by a second survey mailing approximately 30 days later. Those that had already responded were told to ignore the mailing. Twenty incomplete responses were discarded. The mailings yielded 245 usable responses, for a response rate of 12.3%. Although the response rate is low, the rate is similar to that experienced by other surveys when sampling senior officers (Byrd and Turner, 2001; Wisner, 2003). Even with a low response rate, 245 responses from senior officers can provide valuable insight, provided that non-response bias is not an issue. Accordingly, the analysis that follows and all reported statistics are based on a sample of 245 manufacturing firms.

Table 1
Profile of survey respondents

Respondent title	Frequency	Percentage
1. President	19	8
2. CEO	29	12
3. Vice President	76	31
4. Director	93	38
5. Senior Manager	11	5
6. Other	17	6
	245	100

Our study focused on large manufacturing organizations for the following reasons. First, there is evidence to suggest that large organizations differ from small and medium sized organizations in their supply chain relationships, due to larger budgets and differences in the power they exert in these relationships (Benton and Maloni, 2005; Subramani and Venkatraman, 2003; Lee, 2004). Although our study does not focus on issues of power, we wanted to limit our survey to one size category in order to prevent the possibility of firm size having a confounding effect on the findings. Second, our survey only focused on manufacturing firms and did not include service organizations. Service operations are significantly different from manufacturing due to lack of a tangible product, which could create differences in the nature of their organizational collaboration requirements (Chase et al., 2006). For this reason service organizations were deliberately excluded, to eliminate confounding of results.

Specific demographic information of the sample is shown in Table 2, with responding firms including a broad range of companies based on types of markets served and products sold. Diversity also exists based on annual sales and number of employees within the large firm category. Mean sales are $21,210,000 (range is from $4,526,000 to $59,000,000) with a mean number of employees of 48,658 (range is from 3810 to 121,000). Further, the sample was tested for diversity of primary

Table 2
Sample demographic

Industry sub-sector	Frequency	Percentage
1. Miscellaneous manufacturing	61	25
2. Electrical/electronic equipment	44	18
3. Chemical	37	15
4. Fabricated metal	27	11
5. Rubber and plastic	27	11
6. Computer/electronic equipment manufacturing	13	5
7. Machinery manufacturing	7	3
8. Transport equipment manufacturing	6	2
9. Apparel manufacturing	3	1
10. Food manufacturing	2	1
11. Furniture and related product manufacturing	2	1
12. Beverage manufacturing	2	1
13. Wood product manufacturing	2	1
14. Paper manufacturing	2	1
15. Other	10	4
	245	100

process (job shop: 31%; manufacturing cell: 29%; continuous flow: 40%) and diversity of primary products produced (customized: 42%; standardized: 58%). As such, the sample appears to be representative of a wide range of organizations.

4.2. Test for non-response bias

A concern with any survey methodology is the adequacy of the response sample. One method to assess non-response bias is to test for significant differences between early and late respondents (Armstrong and Overton, 1977). In order to ensure adequacy of our data we compared the first and second wave of respondents. *T*-Tests were performed on all 15 questionnaire items used in this study, with no significant differences found between the two samples. Further, Chi-square differences were calculated between respondents and non-respondents for annual sales revenues ($\chi^2 = 4.54$, $p > 0.05$), number of employees ($\chi^2 = 6.23$, $p > 0.05$), and industry ($\chi^2 = 6.82$, $p > 0.05$), and found to be insignificant. These results collectively suggest that non-response bias is not present in the data (Sabherwal, 1999; Teo and King, 1997).

4.3. Construct measures

Table 3 shows the four model factors, the multiple variables used to measure each factor, and summary statistics that include standardized coefficients, standard errors, and *t*-values for variable items. The scale items used to measure these factors are derived from past studies and are described in this section.

Factor 1 measures firm use of e-business technologies. The development of scale items for this factor needed to take into account the definition of e-business technologies, as it can have different meanings to different constituency groups. We defined e-business technology use as use of the Internet, Web, and any web-based applications for conducting intra and inter-firm business processes. This definition differs from the broad meaning of information technology as technology used to acquire, process, and transmit information for more effective decision making (Grover and Malhotra, 1997). Four scale items were used to evaluate firm use of e-business technologies: use relative to industry standards, relative to key competitors, relative to key customers, and extent of reliance on e-business technologies in conducting business operations. The scale items are comparable to those used in a study by Kent and Mentzer (2003). While the scale items in the Kent and Mentzer (2003) study asked respondents whether the company is a "leader" or "on the leading edge" of information technology, our study asks how the company compares relative to industry standards and competition in the use of e-business technologies.

Factor 2 measures intra-organizational collaboration. Three scale items measure this factor: cross-functional collaboration in strategic planning, utilization of an integrated database for information sharing, and sharing of operations information among departments. These variables measure the existence of collaboration and support for information sharing. The first variable, in particular, focuses on collaboration at the strategic level. The importance of aligning functional strategies with those of the firm and making them part of the overall strategy has been well documented in the literature (Skinner, 1969; Hayes and Wheelwright, 1984; Hill, 2000). True strategy formulation requires active participation of functional strategies in order to ensure that the functional strategies are aligned with the overall business strategy (Hill, 2000). The scale items used here are comparable to those used to measure internal collaboration in past studies (Stank et al., 2001).

A fourth scale item was initially introduced for factor 2, but eliminated during the scale purification process. This item measured the direct role of SCM in the strategic planning process of the firm. Direct SCM involvement in strategic planning is considered a necessary component of meaningful SCM implementation (Vickery et al., 1999). However, upon closer examination of the construct, it became evident that the remaining scale

Table 3
Variable and factor listing

Factors and scale items[a]	Standardized coefficient	Standard error	t-Value
F1. Use of e-business technologies (EB)[b]; $\alpha = 0.853$			
EB1. Use of e-business technologies relative to industry standard	0.649	0.023	12.12*
EB2. Use of e-business technologies relative to key competitors	0.612	0.029	12.42*
EB3. Use of e-business technologies relative to key customers	0.672	0.032	11.48*
EB4. Reliance on e-business technologies in conducting business processes	0.589	0.021	11.43*
F2. Intra-organizational collaboration (IC-1); $\alpha = 0.738$			
IC1. Cross-functional collaboration in strategic planning	0.429	0.029	16.23*
IC2. Utilization of integrated database for information sharing	0.528	0.023	16.19*
IC3. Sharing of operations information among departments	0.531	0.027	16.01*
F3. Inter-organizational collaboration (IC-2)[c]; $\alpha = 0.842$			
EC1. Real-time sharing of operations information with suppliers	0.632	0.031	14.56*
EC2. Real-time sharing of cross-functional processes with suppliers	0.741	0.035	15.71*
EC3. Engagement in collaborative planning with suppliers	0.716	0.041	14.23*
EC4. Sharing cost information with suppliers	0.676	0.032	15.65*
F4. Organizational performance (OP); $\alpha = 0.762$			
OP1. Cost improvement relative to performance goals	0.734	0.027	12.36*
OP2. Product quality improvement relative to performance goals	0.628	0.028	13.45*
OP3. New product introduction time relative to performance goals	0.612	0.036	11.51*
OP4. Delivery speed improvement relative to performance goals	0.548	0.031	11.38*

[a] All developed using five-point Likert scale—where 1: strongly disagree and 5: strongly agree; exception are EB1–EB3—where 1: significantly below standard, 3: comparable to standard and 5: significantly above standard.
[b] We uniquely focus on the extent of use of e-business technologies as the Internet, intranets, extranets, and web-based applications in conducting business processes.
[c] Question is directed at information sharing with first tier suppliers.
* Significance at the $p \leq 0.01$ level.

items measure collaboration between functions at the same organizational level, whereas the eliminated scale item measured collaboration between one function, SCM, and strategic organizational planning.

Factor 3 measures the degree of inter-organizational collaboration with suppliers, a key element of SCM (Choi and Hartley, 1996; Tan et al., 1998; Zaheer et al., 1995). SCM enhances competitive performance through internal cross-functional collaboration that is linked with the functions of suppliers and channel members (Monczka et al., 1998; Vickery et al., 1999). Differences in collaboration exist depending on the type of information being shared and the nature of the collaboration process. Our study considered four variables to measure external collaboration: sharing of operations and planning information; sharing of cross-functional processes; participation in collaborative networks with multiple suppliers; and sharing of cost information. Again, the scale items are comparable to those used to measure external collaboration in past research (Stank et al., 2001).

The last factor considered, F4, measures organizational performance. Organizational performance has been measured in numerous ways in the past literature (Handfield and Nichols, 1999; Narasimhan and Das, 1999; Wisner, 2003). These measures typically include the four basic competitive priorities of cost, quality, dependability, and flexibility (Buffa, 1984). More recently innovation has become an added dimension (Ward et al., 1990). However, some researchers have suggested that world-class manufacturers tend to simultaneously pursue multiple performance objectives, rather than merely focusing on one measure (Roth and Miller, 1990). Following the approach of multiple performance objectives, taken in previous studies (Narasimhan and Das, 2001), we treat organizational performance as a composite construct composed of multiple measures. These measures include cost, quality, delivery, and new product introduction time. These scale items are not new and have been used in past studies (Narasimhan and Das, 2001; Scannell et al., 2000).

4.4. Measure development and purification

Using the two-step approach proposed by Anderson and Gerbing (1988), the first step was to purify and test the measurement model. A systematic process was used to determine whether items should be eliminated from the measurement model considering a number of factors including weak loadings, cross loadings, multiple loadings, communalities, error residuals and theoretical determination. As described above, only one item was eliminated.

Cronbach's coefficient alpha and alpha-if-item-deleted, were calculated to determine construct reliability. As shown in Table 3, all Cronbach alpha levels are above 0.70, where 0.70 is the suggested cutoff for established scales (DeVellis, 1991). Prior to purification of scales, the alpha levels indicated that one scale item was below the acceptability level. Purification of scales was then performed through the use of confirmatory factor analysis, with the scale item exhibiting insignificant factor loadings identified and eliminated from the factor measurement (DeVellis, 1991). The elimination of the scale item was also supported by a closer examination of theory, as described in the previous section. Following the purification process alpha levels ranged from 0.738 to 0.853.

5. Results

5.1. The measurement model

Evaluation of the proposed model was made using structuring equation modeling, following the two-step approach recommended by Anderson and Gerbing (1988). The first step involved the development of an acceptable measurement model through the use of confirmatory factory analysis. At this first stage the latent factors of interest are identified, and the relationship between the observed variables and their respective latent factors is tested.

All SEM analyses were conducted using EQS (Bentler, 1997). Table 4 presents results of the measurement model. As recommended by researchers, multiple fit criteria are considered in order to rule out measurement biases (Hu and Bentler, 1999). The fit indices considered are those most commonly recommended for this type of analysis (Bagozzi and Yi, 1998; Byrne, 1994). All the indices were within the recommended range, including ratio of chi-square to degrees of freedom (χ^2/d.f. = 1.92), root mean square error of approximation (RMSEA = 0.05), root mean square residual (RMR = 0.04), goodness of fit index (GFI = 0.96), normed fit index (NFI = 0.96), comparative fit index (CFI = 0.96) and (IFI = 0.96). Collectively these statistics lead us to judge the overall measurement model fit as satisfactory (Byrne, 1994).

Table 4
Fit statistics for measurement model

Fit statistic	Notation	Model value	Acceptable value
Overall fit measures			
Chi-square to degrees of freedom	χ^2/d.f.	1.92	$\leq$2.0
Root mean square error of approximation	RMSEA	0.05	$\leq$0.06
Root mean square residual	RMR	0.04	$\leq$0.05
Goodness of fit index	GFI	0.96	$\geq$0.95
Normed fit index	NFI	0.96	$\geq$0.95
Comparative fit index	CFI	0.96	$\geq$0.95
Incremental fit index	IFI	0.96	$\geq$0.95

5.2. Convergent validity

In order to perform meaningful analysis of the causal model, measures used need to display certain empirical properties. The first of these is convergent validity, which is the degree to which individual questionnaire items measure the same underlying construct. One way to test for convergent validity is to evaluate whether the individual item's standardized coefficient from the measurement model is significant, namely greater than twice its standard error (Anderson and Gerbing, 1988). An analysis of Table 3 reveals that coefficients for all items greatly exceed twice their standard error. Also considering that coefficients for all variables are large and significant provides evidence of convergent validity for the tested items.

5.3. Discriminant validity

In addition to convergent validity, to ensure adequacy of the measurement model it is important to measure that groups of variables intended to measure different latent constructs display discriminant validity. Discriminant validity addresses the extent to which individual items intended to measure one latent construct do not at the same time measure a different latent construct (DeVellis, 1991). We test for discriminant validity in two ways. First, inter-factor correlations are computed for all factors and shown in Table 5. Very high inter-factor correlations, say approaching 1.00, indicate that the items are measuring the same construct, although significant inter-factor correlations may be observed between theoretically related constructs. An analysis of Table 5 reveals the inter-factor correlations to be low.

In addition to the simple inter-factor correlation analysis, discriminant validity was further evaluated through a confidence interval test. A confidence interval of ± 2 standard errors was computed around the correlation estimates between the factors and determined whether this interval includes 1.0. In our test

Table 5
Correlation results

	Use of e-business technologies (EB)	Intra-firm collaboration (IC-1)	Inter-firm collaboration (IC-2)	Organizational performance (OP)
Use of e-business technologies (EB)	1.00			
Intra-firm collaboration (IC-1)	0.314	1.00		
Inter-firm collaboration (IC-2)	0.264	0.362	1.00	
Organizational performance (OP)	0.296	0.241	0.372	1.00

none of the confidence intervals contained 1.0, demonstrating discriminant validity (Anderson and Gerbing, 1988).

5.4. Structural model test results

Fig. 2 presents the results of the structural model tested. Table 6 shows goodness of fit statistics and Table 7 provides a summary of hypothesis test results for the structural model. Overall model fit indices are as follows: ratio of Chi-square to degrees of freedom (χ^2/d.f. = 164.05/85 = 1.93), root mean square error of approximation (RMSEA = 0.05), root mean square residual (RMR = 0.04), goodness of fit index (GFI = 0.97), normed fit index (NFI = 0.96), comparative fit index (CFI = 0.96) and incremental fit index (IFI = 0.97). A comparison of these values against those recommended in the literature suggests that the model is satisfactory (Hu and Bentler, 1999). All paths are statistically significant at the 0.05 level.

This serves as the basis of evaluation for our hypotheses:

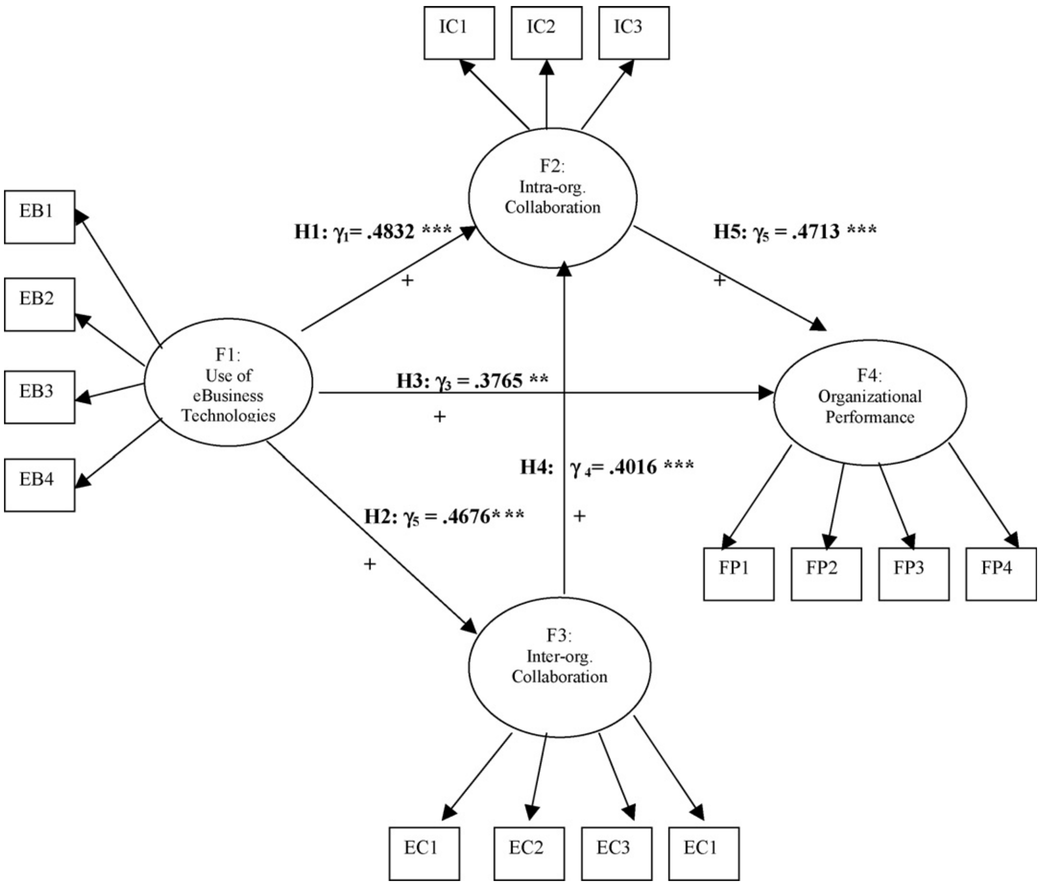

Fig. 2. Structural model. Significant at: $^{*}p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$.

H1. Firm use of e-business technologies (EB) has a direct and positive impact on intra-organizational collaboration (IC-1). This hypothesis is supported, as the parameter estimate (0.48) is significant.

H2. Firm use of e-business technologies (EB) has a direct and positive impact on inter-organizational collaboration (IC-2). This hypothesis is supported, as the parameter estimate (0.46) is significant.

H3. Firm use of e-business technologies (EB) has a direct and positive impact on organizational performance (OP). This hypothesis is supported, as the parameter estimate (0.37) is significant.

H4. Inter-organizational collaboration (IC-2) has a direct and positive impact on intra-organizational collaboration (IC-1). This hypothesis is supported, as the parameter estimate (0.40) is significant.

H5. Intra-organizational collaboration (IC-1) has a direct and positive impact on organizational performance (OP). This hypothesis is supported, as the parameter estimate (0.47) is significant.

We note that in addition to the proposed model, alternative structural models were tested as part of our analysis. However, the presented model proved to have the best fit based on the discussed measures. Our study documents that use of e-business technologies has both a direct and indirect impact on firm performance, with the indirect effect on performance being significant (0.31) at the $p \leq 0.01$ level.

Note that we did not hypothesize a direct relationship from inter-organizational collaboration to firm performance based on our literature review. The Lagrange Multiplier (LM) test for omitted paths did not indicate that such a relationship would be significant. This is further supported by the computed indirect effect of inter-organizational collaboration on performance, which was significant (0.19) at the $p \leq 0.05$.

Finally, two alternative models were tested. In the first model a path, γ_6, was added from inter-organizational collaboration (IC-2) to organizational performance (OP) to test the direct effect of this construct. The added path was found to be insignificant at the $p < 0.05$ level ($\gamma_6 = 0.158$). A second model was then tested that included a path from intra-organizational collaboration (IC-1) to inter-organizational collaboration (IC-2). With this second model we wanted to test a mutual effect of intra and inter-organizational collaboration on one another. The path from intra to inter-organizational collaboration was found to be insignificant as well at the $p < 0.05$ level ($\gamma_4 = 0.179$).

To gain greater insight into the meaning of our findings regarding the issue of a one way mediated relationship between intra- and inter-organizational collaboration, we contacted 15 randomly selected survey respondents for their interpretation of these findings. Six were unable to take the time to talk with us for a variety of reasons, with nine available for a short (15 min) telephone conversation. All of the nine we spoke with stated that in their experience lack of collaboration internally constraints external collaboration, which supports the argument of some researchers in this area (Subramani, 2004). However, five of the respondents commented that our findings are likely related to the variables used in defining inter-organizational collaboration, which focus on operational rather than strategic collaboration issues (EC1: real-time sharing of operational information; EC2: real-time sharing of cross-functional planning; EC3: engaging in collaborative planning; EC4: sharing cost information with suppliers). In fact, one respondent pointed out that in his opinion this relationship may not necessarily be true for strategic types of collaboration. Although the variables used in our study for inter-organizational collaboration are derived from the literature, they indeed focus on operational issues of collaboration rather than strategic issues. Our study provides interesting findings regarding how e-business technology use impacts collaboration and performance, and the complexity of collaboration. However, the comments from the follow-up interviews, albeit unstructured and statistically insignificant, raise two important issues. The first issue is that future research needs to look at the construct of collaboration at a much greater level of detail. Second, the conceptual model tested does not eliminate other models that may provide a better explanation of these relationships.

6. Discussion and implications

The purpose of this paper was to propose and test a model of the relationship between organizational use of e-business technologies, intra and inter-organizational collaboration, and performance. A number of important findings emerge that have both theoretical and managerial implications. First, a significant contribution of this study is the empirical test of theoretical assumptions in the extant literature of the influence of e-business technologies on collaboration and organizational performance. e-Business technology use is shown to have a significant direct impact on performance and a significant impact on both intra and inter-organizational collaboration. This finding underscores the important

Table 6
Goodness of fit of the structural equation model

Fit statistic	Notation	Model value	Acceptable value
Overall fit measures			
Chi-square to degrees of freedom	χ^2/d.f.	1.93	≤2.0
Root mean square error of approximation	RMSEA	0.05	≤0.06
Root mean square residual	RMR	0.04	≤0.05
Goodness of fit index	GFI	0.97	≥0.95
Normed fit index	NFI	0.96	≥0.95
Comparative fit index	CFI	0.96	≥0.95
Incremental fit index	IFI	0.97	≥0.95

Table 7
Summary of hypothesis test results for structural model

Hypothesis	Path	Path coefficient	R^2	Hypothesis supported?
H1	γ_1 e-business → intra-organizational collaboration	0.4832^{***}	0.410	Yes
H2	γ_2 e-business → inter-organizational collaboration	0.4676^{***}	0.347	Yes
H3	γ_3 e-business → performance	0.3765^{**}	0.167	Yes
H4	γ_4 inter-organizational collaboration → intra-organizational collaboration	0.4016^{***}	0.313	Yes
H5	γ_5 intra-organizational collaboration → performance	0.4713^{***}	0.387	Yes

Path significant at: $^{**}p < 0.05$; $^{***}p < 0.01$.

role e-business technology plays in the functioning of supply chain organizations.

This research also suggests that collaboration is not synonymous with e-business technology use. Rather, e-business technology use is a separate construct that promotes both intra and inter-organizational collaborative relationships. This is noted as occasionally companies presume that having information technology in place automatically assumes that collaboration exists. Collaboration is a result of human interactions which can only be supported by IT, one of which are e-business technologies, but not replaced. This is an important point for managers as they consider funding for various IT initiatives. Based upon the findings of this study, e-business technology efforts that particularly promote collaboration should be given greater consideration.

Another important finding is with regard to the significant impact of intra-organizational collaboration on performance. Although this finding is not new, it does validate and further confirm the important role internal collaboration serves. The significant impact of intra-organizational collaboration on performance suggests that companies should invest in strategies that promote cooperation and integration across the functions of the organization. As use of e-business technologies is shown to promote internal collaboration, companies should also consider investing in these types of information technologies.

Last, our model supports the finding that inter-firm collaboration influences intra-organizational collaboration, which in turn impacts performance. This finding is important as it supports previous findings. This finding, however, may not be surprising. By engaging in inter-organizational collaboration companies automatically force higher levels of internal collaboration. Benefits of collaboration appear to be synergistic in nature. They help members of the organization access information in a timely manner, process relevant information efficiently, and make informed decisions both internally and across enterprises.

There is an important caveat to our findings that was raised in the small number of follow-up interviews. The variables used in our study for inter-organizational collaboration, although derived from the literature, focus on operational issues of collaboration rather than broader strategic issues. The comments from the follow-up interviews suggest that these findings may not necessarily hold true for strategic issues of collaboration. This underscores the complexity of collaboration and that an important issue for future research may be to look at this construct at an even greater level of detail.

7. Limitations and future research

A number of limitations of the current study need to be noted, as well as directions for future research. Our study focused on the impact of e-business technologies exclusively, and not other types of information technologies. For example, wireless devices and mobile business solutions are yet another IT that have the potential to make significant changes in supply chain management (Shankar and O'Driscoll, 2002). Given the large expenditures IT investments require, it may be important for future work to consider the impact of different types of information technologies on firm performance. For example, one functional classification of IT is provided by Barki et al. (1993), where IT is aggregated into six categories: transaction processing systems, decision support systems, interorganizational systems, communication systems, storage and retrieval systems, and collaborative work systems. Another classification of IT is provided by Kendall (1997), where IT is divided into two categories: production-oriented information technologies and coordination-oriented information technologies. Regardless of classification, it can be assumed that some of these technologies have a more direct impact on collaboration and integration than others. Future research should elaborate on our initial findings to consider the impact of specific information technologies on collaboration and firm performance.

Some studies suggest that there is a recommended sequence in using information technology in order to achieve supply chain integration (Narasimhan and Kim, 2001). These studies suggest that in order for information technology to be implemented successfully there needs to be coordination and a functional relationship between the stage of supply chain integration and the utilization of IT. As collaboration is an integral part of supply chain integration it seems that this would have an impact on collaboration as well. It also suggests the complexity of this issue. The model tested in our current study is somewhat simplistic. Future studies should consider expanding this relationship to include the stage of supply chain integration.

Our research considers collaboration as two constructs, one for internal and one for external collaboration. In fact, collaboration can be viewed in stages, from simple information sharing to true collaboration (Sabath and Fontanella, 2002). Future research should consider the relationship between specific types of information technologies and their linkage to specific collaboration needs. This type of work could potentially provide interesting findings for use of information technology in business.

Our study also has limitations due to the nature of empirical data that it is based on. First, the random errors inherent in this type of data may cause differences in the scale results using confirmatory factor analysis, with differing data sets. Scale development, purification, and validation, is an ongoing process that needs to be developed longitudinally and across multiple data sets. Consequently, future research will need to reexamine the measures used in this study.

Another limitation of our study relates to characteristics of the sample upon which the hypotheses are tested. Larger studies on broader samples should evaluate whether these results are truly generalizable. Also, e-business technology use is pervasive throughout all types of industries. Our study was limited to primarily large manufacturing firms, in communicating with their suppliers. Similar measures need to be developed for a broader range of firms, such as firms in the service environment, and benefits compared for downstream versus upstream collaboration.

Despite the discussed limitations, our research provides support for the positive influence of one type of IT – e-business technologies – on organizational collaboration and performance. Some authors have questioned the tangible benefits associated with the large and rapidly growing expenditures toward IT, and have encouraged empirical research to shed light on this issue (McAfee, 2002). Our study attempts to provide such empirical evidence by elucidating the role of e-business technologies in organizations.

8. Conclusion

The capability of information technology (IT) and it use have dramatically increased over the recent past. Investments in IT are important decisions for companies as they involve large capital expenditures. The literature has viewed IT as an enabler of internal and external firm collaboration, which is the foundation of supply chain management. e-Business technologies, namely the Internet, Web, and web-based applications, have had a particularly profound impact on supply chain organizations. Their use is expected to improve organizational collaboration and information sharing and, in turn, organizational performance. Our study tested a model of the relationship between firm use of e-business technologies, intra and inter-organizational collaboration, and organizational performance, using empirical data. Our findings show that firm use of e-business technologies impacts performance both directly and by having a positive impact on intra and inter-organizational collaboration. Intra-organizational collaboration is shown to have a strong direct impact on performance and, in turn, is impacted by inter-organizational collaboration. These findings underscore the importance for companies to promote collaboration internally and invest in e-business technologies that serve as facilitators.

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