The extended supply chain
A statistical study

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Abstract *The realities of today's digital economy are requiring and enabling dramatically improved levels of supply chain efficiency and effectiveness. The business-to-business (B2B) or extended digital supply chain, enabled by Internet technologies, is specifically being offered as the next competitive weapon. This paper offers definitions and measures of the extended supply chain construct and reviews the results of an ongoing benchmarking research project completed in cooperation with the US and European Supply Chain Councils. This study found that Internet usage is just beginning in both the USA and Europe but has significant relationships to cross-company (B2B) integrating practices that are key components of the extended supply chain and supply chain management performance.*

Introductions and background

The Internet has the capacity to change everything and is doing so at a far greater speed than the other "disruptive" technologies of the twentieth century, such as electricity, the telephone and the automobile. "In five years time, all companies will be Internet companies or they won't be companies at all", says Andy Grove, Chairman of Intel (*The Economist*, 1999a)

"How you gather, manage and use information will determine whether you win or lose", says Bill Gates of Microsoft (Gates, 1999). Having information available to every customer, when and where they want it, and at a cost affordable by almost everyone has dramatically shifted the balance of power and customer expectations. Customers, both end consumers and intermediaries, are expecting dramatically more – more information, more speed, more flexibility, more cooperation/collaboration and more service. Understanding and leveraging this is the imperative for survival in the digital economy.

Lou Gerstner of IBM stated, "The storm that's arriving – the real disturbance in the force – is when the thousands and thousands of institutions that exist today seize the power of this global computing and communications infrastructure and use it to transform themselves. That's the real revolution" (*The Economist*, 1999b).

The supply chain configurations evolving in today's digital economy reshape the historical chain into networks or business-webs (Tapscott *et al.*, 2000). These network configurations reflect the interconnected roles and activities within a cross-enterprise supply chain. The historical legal and organizational structures are no longer the basis of competition. The evolving inter-connected supply chain webs are the new business-to-business configurations and the key competitive levers in the economy.

In order to examine the progress of this revolution with regard to supply chain management (SCM), a research study began in 1997 to investigate the factors involved in the management of a supply chain. The results of this research offered the concept of a maturity level for a company's SCM processes (McCormack, 1999a, b; McCormack and Johnson, 2000). At that time, the most advanced level of maturity, extended (integrating with supply chain partners outside of company boundaries), could not be adequately measured. This level required a company-to-company technology infrastructure, the Internet, that was not yet fully in use. With the recent acceleration of Internet usage, it is now possible to measure the impact on these activities. With the Internet as a catalyst, supply chain networks are forming to connect, interact and build powerful relationships.

This study, phase II of the ongoing research with the Supply Chain Council, attempts to measure and investigate Internet usage and the impacts on specific SCM practices in the extended supply chain.

Literature review

The business-to-business (B2B) interactions, or what has been called the extended supply chain, have only begun to be defined and investigated as a realizable concept. Not only is the definition of this concept unclear, very little quantitative research has been done investigating the impact of the Internet on this concept.

To date, much of the quantitative research concerning SCM performance and technology has been in the area of logistics. These studies have focused on the evaluation of the impact of very specific programs such as the use of EDI technologies, vendor-managed inventory, and automatic replenishment programs (Daugherty et al., 1999; Droge and Germain, 2000; Waller, 1999). An exception is the study involving inter-firm coordination in food industry supply chains (Stank et al., 1999; Bowersox et al., 2000). This study examines the benefits of integrated SCM processes and proposes that SCM extends a firm's capabilities by coordinating operations to encompass source, make and delivery processes in collaboration with channel partners and suppliers. A shift in channel arrangements from loosely linked groups of businesses to coordinated enterprises is described. The shortfall in this study is that the only technology examined is EDI, leaving the impact of the Internet on SCM unexamined.

Forrester Research, an international research firm, predicted in December 2000 that enterprises would connect their supply chains to the Internet, forming network supply chains (NSC). They define this as "a network on inter-enterprise supply chain events connected through a private or public eMarketplace" (Homs, 2000). Although they clearly state that there are few defined practices in place for this concept, they offer a three-phase approach to achieve NSC status. Phase one involves integrating the planning activities, orders and logistics between members of the NSC, phase two involves instituting cooperative advanced planning, scheduling and synchronization,

and phase three results in full NSCs. Forrester offers clear descriptions of the practices needed to achieve phases one and two but phase three, actually reaching NSC status, is vague.

AMR Research, a Boston-based research firm focusing on manufacturing issues, predicted that electronically connected trading communities will form, driven by the Internet and available via Internet-based applications for connecting and interacting (AMR Research, 2000). They propose that vendor managed inventory (VMI), supplier collaboration and collaborative planning, forecasting and replenishment (CPFR) will be key externally focused programs that will be significantly enabled by the use of Internet technologies.

Much of the literature concerning the impact of the Internet on SCM practices and performance is speculative since Internet usage in this area is not widespread, thus limiting both case study and quantitative research. Most of the case study literature suggests the Internet will help create a seamless, integrated supply chain of close collaborative relationships with integrated data and business processes (Ljungdahl, 2000; Kahl and Berquist, 2000). One of the few quantitative studies (mentioned earlier), completed by Michigan State University, proposes a model consisting of logistic competencies (Bowersox *et al.*, 2000; Stank *et al.*, 1999). These are internal integration, customer integration, relationship integration, technology and planning integration, measurement integration and supplier integration. This study provides solid evidence of the benefit to SCM by extending the supply chain to include suppliers and customers but, as mentioned earlier, does not examine the impact of the Internet on SCM.

Lee (2000), a leading SCM researcher, offers the concept of supply chain integration. This concept of an integrated supply chain that makes smart use of information to orchestrate the activities of the chain is described in three levels. Level one is information sharing, the foundation of SC integration. Level two is coordination and level three is organizational linkages. Although Lee (2000) does not discuss the impact of the Internet directly, it is obvious that levels one and two can be dramatically affected.

While much of the literature supports the benefits of extending the supply chain to form a network of coordinated activities, the impact of the Internet on this goal has been quantitatively unexplored.

Research propositions and scope of study

In addition to investigating the levels of Internet usage as applied to company-to-company interactions, this study attempts to investigate the following research propositions concerning Internet usage, SCM performance and cross-company SCM practices. Figure 1 depicts the proposed relationships.

- there is a significant relationship between Internet usage and SCM performance; and
- there is a significant relationship between the adoption of cross-company SCM practices (integrating practices) and Internet usage.
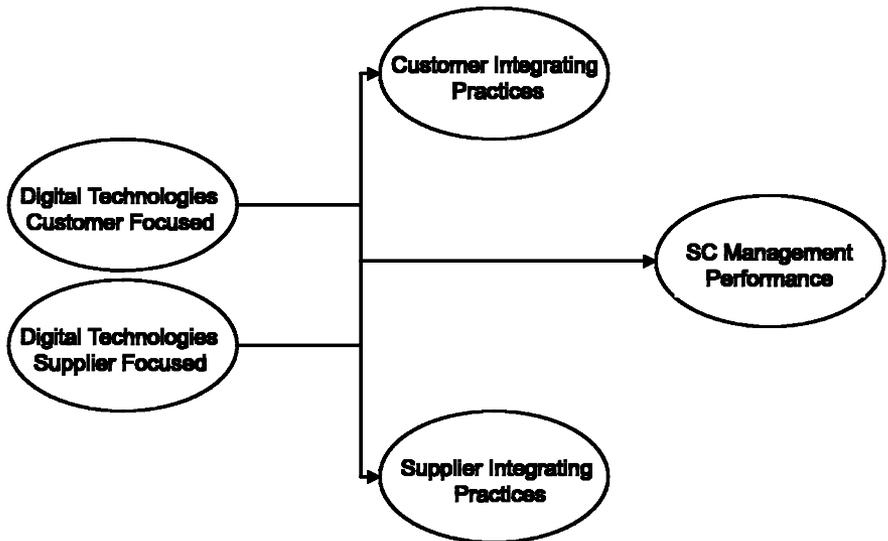
The unit of analysis for this study is a member firm in a supply chain, specifically the interactions between partners that attempt to manage and coordinate the activities in this chain. These interactions across company boundaries and are generally referred to as SCM. Only specific SCM practices that cross company boundaries are included in this study.

Defining the constructs
Building upon the literature review, expert interviews and the results of past research, a definition of the extended supply chain construct can be proposed as:

Extending outward beyond company boundaries to your customers and suppliers and connecting with them through the use of digital technologies and integrating practices.

In this study, we divide this construct into the two components of digital technologies and integrating practices.

Digital technologies (Internet usage)
Digital technologies are the nervous system of the new economy. The pervasive use of these technologies, enabling the integration of company-to-company supply chains, is a critical strategy in building the extended supply chain. These technologies are network based (the Internet) and communication/information transfer is their main function (e-mail, online chat, file transfer, shared programs). For this study, we used the label of digital technologies to represent Internet usage. This concept is defined as:

- interaction through e-mail and online chat;
- gathering of general information about a customer or supplier;

- placing orders for goods or services; and
- gathering specific interaction data such as usage, forecasts, complaints, or other performance data.

Integrating practices
Integration is not just communicating across canyons created by an organization's functions, departments or legal structures. Integration is open and somewhat uncontrolled. Sharing the rewards and consequences of actions taken and decisions made is an integrating mechanism within a company and with supply chain partners. Co-habitation, shared employees, shared information and shared secrets are also key integrating mechanisms. For this study, integrating practices were divided into practices that extend outward to suppliers and practices that extend outward to customers.

Extending outward to suppliers is defined as the purposeful inclusion of suppliers in investments, decisions, facilities, social functions and joint actions. Extending outward to customers is defined as the purposeful inclusion of customers in investments, decisions, faculties, social functions and joint actions, and is the flip side of extending outward to suppliers.

As further validation of the definitions proposed in this study, several focus groups and expert interviews were conducted with SCM practitioners. There was general agreement that the definitions proposed captured the constructs.

Measures
The measures representing the integrating practices in the extended supply chain were extracted from earlier research with the Supply Chain Council (McCormack, 1999a, b). This original research developed overall SCM measures through a literature review, and a series of interviews and focus groups with experts and SCM practitioners held from 1996 through 1999. The results of these interviews and focus groups drove the development of a starter list of measures (survey questions) that were later reduced through testing and analysis. These initial survey questions were then organized into the "Supply chain operations reference model" (Supply Chain Council, 2000) areas and sent to several experts for evaluation and feedback. This initial survey was then tested within a major electronic equipment manufacturer and with several supply chain experts. Survey questionnaires were developed using a five-item Likert scale measuring the frequency of the practice consisting of: 1 – never or does not exist; 2 – sometimes; 3 – frequently; 4 – mostly; and 5 – always or definitely exists.

The integrating practice measures for the extended supply chain construct were extracted from the original research and organized by supplier (nine items) and customer (nine items) categories. The numerical designations indicate the applicable section within each area of the supply chain operations reference model (plan, source, make, deliver).

Extending outward to suppliers

- *P15* – Does this team (operations strategy team) participate in supplier relationships?
- *S8* – Do you share planning and scheduling information with suppliers?
- *S9* – Do key suppliers have employees on your site(s)?
- *S10* – Do you "collaborate" with your suppliers to develop a plan?
- *S11* – Do you measure and feed back supplier performance?
- *M5* – Are supplier lead times a major consideration in the planning process?
- *S6* – Do suppliers manage "your" inventory of supplies?
- *S5* – Do you have strategic suppliers for all products and services?
- *S7* – Do you have electronic ordering capabilities with your suppliers?

Extending outward to customers

- *P15* – Does this team (operations strategy team) participate in customer relationships?
- *P25* – Does your demand management process make use of customer information?
- *D9* – Are the projected delivery commitments given to customers credible (from the customer's view)?
- *D4* – Are the customer's satisfied with the current on-time delivery performance?
- *M13* – Is your customers planning and scheduling information included in yours?
- *D3* – Do you track the percentage of completed customer orders delivered on time?
- *D12* – Do you automatically replenish a customer's inventory?
- *P23* – Is a forecast developed for each customer?
- *P6* – Has the business defined customer priorities?

The digital technology or Internet usage specific measures (DT#) were developed for this study through expert interviews, focus groups and validation activities. Measure categories were developed matching the construct definitions along with the starter list of measures developed during the previous research, literature review and interview results. The scale used for integrating practice measures was also used for digital technology measures. The following are the resulting measures used in this study.

Customer interaction related

- *DT1* – Do your customers interact with you through the Internet (e-mail, online chat)?
- *DT2* – Do your customers gather information about you (and your products) through the Internet?
- *DT3* – Do your customers place orders for your goods and services through the Internet?
- *DT4* – Do you gather customer data (usage, forecast, ideas, complaints) through the Internet?

Supplier interaction related

- *DT5* – Do your suppliers interact with you through the Internet (e-mail, online chat)?
- *DT6* – Do you gather information about your suppliers (and their products) through the Internet?
- *DT7* – Do you place orders for your suppliers' goods and services through the Internet?
- *DT8* – Do you gather supplier data (performance, forecast, ideas) through the Internet?

SCM performance was measured using a self-rating by the participant. The survey contained a question in each of the four supply chain operations reference model areas asking the participant to rate the performance of the specific SCM process on a scale of 1 to 5 by agreeing or disagreeing with the statement "Overall, this decision process performs very well". For a total SCM performance score, the individual answers were summed to create one score that was used in the correlation analysis.

Data gathering and analysis
Sample
The survey questionnaires used in this study were distributed to supply chain council members in July 2000. A total of 25 companies participated and 38 usable surveys were returned. Tables I and II represent the industry make up of the respondents.

Analysis of data
As a general validation review, frequencies and distributions were developed and compared to the overall database compiled from the multi-year study. In general, the US and European sample tracked each other in regards to integrating practices and were either at or above the mean of the overall database. The conclusion was that the data set included companies with representative usage of integrating practices.

In regards to Internet usage, Figure 2 depicts the digital technology results. The horizontal bar shows the mean of the total sample, the diamond denotes the mean of the European sample, the square represents the mean of the North American sample and the percentages indicate the distribution of respondents' answers (1 through 5). In general, the North American sample showed higher Internet usage than Europe, which makes sense. There is a general acceptance that the USA is ahead of Europe in this regard.

In general, Internet usage appears to be in an early phase of adoption. Basic e-mail interaction seems common between both suppliers and customers, while taking orders online was surprisingly low. Considering the e-commerce focus during the last few years, it was expected that taking orders online from your customers or placing orders online from your suppliers would be almost commonplace. However, over 50 percent of respondents never take or place orders online. The gathering of information about customers and suppliers was also lower than expected. This might be explained by the fact that in B2B interactions, the set of suppliers and customers is very stable and well known, reducing the need for information gathering.
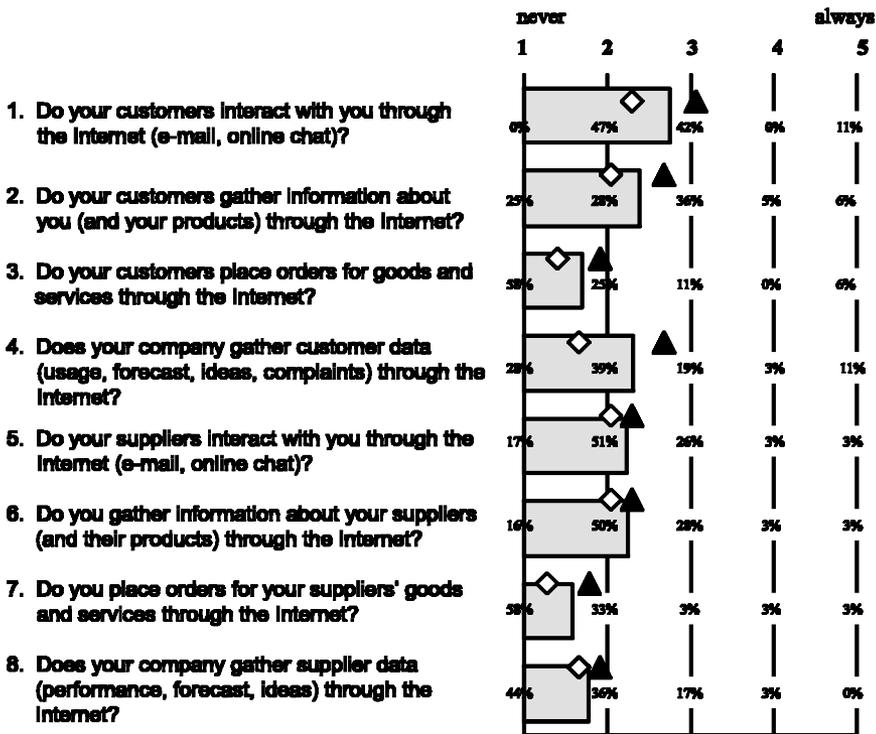
In order to answer the specific research propositions, a detailed correlation analysis was performed. The results are in Table III. Correlation results measure the strength of a relationship from 0 to 1. No relationship is 0 and 1 is a perfect relationship. The relationships can also be positive or negative, meaning the variables move in opposite directions. Statistical significance was also measured using a Pearson Correlation two-tailed test. In this study, only

Sector	Industry	Percentage of respondents
1	Semiconductor	7.0
2	Pharmaceutical/medical	39.0
3	Chemicals	7.0
4	Industrial products	20.0
5	Electronics	20.0
6	Other	7.0

Table I.
Industries represented – European (including China, Australia and Japan)

Sector	Industry	Percentage of respondents
1	Apparel	5.0
2	Pharmaceutical/medical	5.0
3	Chemicals	5.0
4	Industrial products	24.0
5	Electronics	9.0
6	Aerospace and defense	33.0
7	Transportation	5.0
8	Other	14.0

Table II.
Industries represented in the US study

1. Do your customers interact with you through the Internet (e-mail, online chat)?
   0% | 47% | 42% | 6% | 11%

2. Do your customers gather information about you (and your products) through the Internet?
   25% | 28% | 36% | 5% | 6%

3. Do your customers place orders for goods and services through the Internet?
   50% | 25% | 11% | 0% | 6%

4. Does your company gather customer data (usage, forecast, ideas, complaints) through the Internet?
   28% | 39% | 19% | 3% | 11%

5. Do your suppliers interact with you through the Internet (e-mail, online chat)?
   17% | 51% | 26% | 3% | 3%

6. Do you gather information about your suppliers (and their products) through the Internet?
   16% | 50% | 28% | 3% | 3%

7. Do you place orders for your suppliers' goods and services through the Internet?
   58% | 33% | 3% | 3% | 3%

8. Does your company gather supplier data (performance, forecast, ideas) through the Internet?
   44% | 36% | 17% | 3% | 0%

Key: Bar = Benchmark Database Mean ▭
Diamond = European Mean ◇
Triangle = North American Mean ▲
XX% = Benchmark Database Response

Figure 2.
Digital technology
(Internet usage) results

correlations above the 95 percent (0.05) significance level were considered significant.

Results and findings

The correlation results were used to examine the two research propositions:

   P1. There is a significant relationship between Internet usage and supply chain management performance.

Four digital technology questions were statistically related to overall SCM performance. These were:

   (1) *DT1.* Do your customers interact with you through the Internet (e-mail, online chat)? (0.364 correlation, 0.05 sig.)

   (2) *DT2.* Do your customers gather information about you (and our products) through the Internet? (0.438 correlation, 0.01 sig.)

(3) *DT4.* Do you gather customer data (usage, forecast, ideas, complaints) through the Internet? (0.461 correlation, 0.01 sig.)

(4) *DT7.* Do you place orders for your suppliers' goods and services through the Internet? (0.413 correlation, 0.05 sig.)

Three of the four customer-oriented questions were significant while only one of the four supplier-oriented questions was significant. This suggests that Internet usage has more of an impact on SCM performance when used in interacting with customers (e-mails, gathering information and data), but not in accepting orders from customers. It also suggests that placing orders with suppliers over the Internet has a positive impact on performance but interacting and gathering information does not. These results suggest a benefit from Internet usage slanted toward the supplier role, with the exception of efficient processing of orders from a customer with a supplier.

P2. There is a significant relationship between the adoption of cross-company SCM practices and Internet usage.

When investigating the relationship between cross-company SCM practices and Internet usage (DT questions), 13 relationships were significant. Tables III and IV contain the details.

Some top-line analysis suggests that automatic replenishment processes and demand management (forecasting and planning) processes can be positively impacted by use of the Internet (questions D12, P25, M13). The results also suggest that interacting with customers through the Internet can impact customer satisfaction with on-time delivery performance. What is most interesting is the negative relationship between question DT3, customers placing orders through the Internet, and a business defining customer priorities. This indicates that the more customer orders taken through the

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DT1 Do your customers interact with you though the Internet (e-mail, online chat)?
        P25 (0.445) Does your demand management process make use of customer information?
        D4 (0.409) Are the customers satisfied with the current on-time delivery performance?
        D12 (0.447) Do you automatically replenish a customer's inventory?

DT2 Do your customers gather information about you (and your products) through the Internet?
        D4 (0.473) Are the customers satisfied with the current on-time delivery performance?

DT3 Do your customers place orders for your goods and services through the Internet?
        P6 (–0.383) Has the business defined customer priorities?

DT4 Do you gather customer data (usage, forecast, ideas, complaints) through the Internet?
        M13 (0.480) Is your customer's planning and scheduling information included in yours?
        D12 (0.447) Do you automatically replenish a customer's inventory

Note: Significant correlations are shown in parentheses

Table III.
Digital technology correlations to customer integrating practices

DT1	Do your suppliers interact with you though the Internet (e-mail, online chat)?	
	S6 (0.447) Do suppliers manage "your" inventory of supplies?	
DT6	Do you gather information about your suppliers (and their products) through the Internet?	
	S6 (0.428) Do suppliers manage "your" inventory of supplies?	
DT7	Do you place orders for your suppliers' goods and services through the Internet?	
	S6 (0.556) Do suppliers manage "your" inventory of supplies?	
	S8 (0.397) Do you share planning and scheduling information with suppliers?	
	S7 (0.352) Do you have electronic ordering capabilities with your suppliers?	
DT8	Do you gather supplier data (performance, forecast, ideas) through the Internet?	
	S6 (0.404) Do suppliers manage "your" inventory of supplies?	

Note: Significant correlations are shown in parentheses

Internet, the less you need to prioritize or rank your customers' orders. It would also suggest that the more orders you take through the Internet, the less you need to expedite, the main reason for customer priorities.

With regard to interacting with suppliers, six relationships were significant. Tables III and IV contain the details.

What comes through very strongly here is that Internet usage strongly impacts supplier management of a customer's inventory (question S6) in all supplier related digital technology areas. This is consistent with the earlier findings concerning interactions with customers, but even more significant here. The sharing of planning and scheduling information with suppliers and electronic ordering capabilities were also positively impacted by Internet usage. No other relationships with the nine supplier integrating practices were significant. This is a surprising result since there was an expectation that measuring supplier performance and collaborating with suppliers to develop a plan is impacted by Internet usage. This could indicate that these activities could be successful without digital technologies.

In summary, there is considerable support for both *P1* and *P2*. The data suggest that Internet usage can have a significant impact on cross-company practices in the areas of VMI, planning and demand management. The data also suggest that Internet usage can also positively impact overall SCM performance.

Conclusions and implications
In B2B, a customer- and process-focused integration of all the SCM aspects is vital. The Internet has provided the ability to easily send and receive information globally. The results of this study suggest that use of the Internet to connect outward to customers and suppliers can improve SCM performance. The results of this study also suggests that a participant in a supply chain can benefit more from extending outward to its customers than back toward its suppliers.

Customers appear to be more satisfied with on-time delivery performance when information is made available or provided through the Internet. In addition, the results suggest that when the provided customer information is part of the demand management and the planning and scheduling processes, supply chain performance is improved. The inverse correlation between the use of the Internet and the need for the business to define customer priorities, a key indicator of expediting, suggests that disruptions and unplanned orders are minimized when leveraged by the Internet. With the frequent interaction enabled by the Internet, the SCM processes may run more smoothly.

This study strongly suggests that Internet usage will enable companies to extend outward to suppliers to share forecasting, planning, and scheduling information. This sharing of predictions can significantly reduce inventory held just in case and increase the confidence in suppliers' commitments. Both of these lead to less inventory and improve synchronization of supply chain activities. Also strongly suggested in this study was that connection strategies such as vendor management inventory are aided by the use of the Internet. This would further improve the synchronization of a supply chain's activities.

Clearly suggested by this research project is that company-to-company supply chains have begun to interact with their partners using the Internet. They are sharing data. They are exchanging e-mails. They are providing timely digital orders and some have begun establishing a collaborative effort with their partners. As organizations realize the benefits of supply chain partner collaboration, these organizations will no longer view themselves as a separate entity, but will view themselves as a partner of their supply chain network or business web. This integration of supply chain partners will better position them to fulfill the new customer demands requiring increased agility, versatility, and synchronization of the SCM processes. The extended supply chain will become the key competitive strategy of this new digital economy.

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