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Making sense of the e-supply chain landscape: an implementation framework

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Abstract

Firms are increasingly embracing integrated Web-based or e-supply chains because such chains are believed to enhance efficiency and competitiveness. The e-supply chain movement has received a boost from a variety of off-the-shelf supply chain software solutions that have appeared on the market. However, in the excitement about these software solutions, it is often overlooked that creation and implementation of integrated supply chains requires tremendous resources, a great deal of management time and energy, large organization-wide changes, huge commitment from suppliers/partners, and sophisticated technical infrastructure. Further, a standard solution cannot fit all types of supply chains because different chains have different requirements. Then, many firms may not want to use such off-the-shelf software solutions because they already have some components of an e-supply chain in place. Therefore, before embracing e-supply chains, firms need to understand different options for creating supply chains from among which they can pick the option they can successfully implement, keeping in view their resources and their ability to handle associated challenges. In this paper we develop a framework that captures various approaches to supply chain implementation for different supply chain requirements. To develop the framework, we draw on research in a wide variety of areas, discussions with professionals who were involved in creating e-supply chain systems, and a detailed study of two companies that recently installed e-supply chain systems.

Keywords: Supply chain management; Internal integration of operations; External integration with business partners; Web-based supply chain systems

1. Introduction

A supply chain refers to a connected series of organizations (e.g., suppliers, original equipment manufacturer, distributors, transporters, etc.), resources, and activities involved in the creation

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and delivery of value, in the form of both finished products and services to end customers (Raman & Singh, 1998; Copacino, 1997; Morgan, 1997; Henriott, 1999; Hickey, 1999; Collett, 1999; Zwass, 1996). Business firms are increasingly embracing integrated supply chains because they promise cost reduction, efficiency, and effective fulfillment of market demand (Fisher, 1997; Hutt & Speh, 2001; Magretta, 1998; Kalakota & Robinson, 1999). As business-to-business transactions are increasing on the Internet, it is becoming critical for firms to rely on Web-based supply chains or e-supply chains in order to provide almost real-time response to market conditions that e-commerce has come to signify (Henriott, 1999; Hsu & Pant, 2000; Mecker, 1999; Raghunathan & Madey, 1999; Sheridan, 1998; Glushko, 1999).

In recent times, the e-supply chain movement has received a boost from a variety of supply chain software packages that are now available in the market (for example, software from i2 Technologies and Manugistics and integrated suites like mySAP and Oracle11i). Suppliers of these packages make many claims about the effectiveness of their products in creating integrated supply chains and thus improving both efficiency and responsiveness to market needs. There is also a great deal of excitement in the market about how these packages can fully integrate the supply chain of a company and bring manifold improvements in its competitiveness.

While software indeed has a role in improving integration and in enhancing the efficiency and effectiveness of a supply chain, it will be erroneous to assume that creating integrated e-supply chains is as simple as buying and installing a software package. Creation and implementation of highly integrated supply chains can require tremendous resources, a great deal of management time and energy, large organization-wide changes, huge commitment from suppliers/partners, and sophisticated technical infrastructure. In other words, while there are benefits of creating integrated supply chains with these software packages, there are numerous challenges and costs of undertaking such an endeavor. However, the enthusiasm in the marketplace about supply chain software packages seems to be ignoring the challenges involved in the implementation of e-supply chains.

The other impression that is being created about supply chain software is that e-supply chains basically refer to highly integrated supply chains implemented through the use of standard, off-the-shelf software packages. However, this impression has major problems as different firms have different supply chain requirements, i.e., not all supply chains are created equal. Thus, a standard solution cannot fit them all. Furthermore, not all firms will create supply chain systems from scratch. Many firms already have some components of supply chain systems in place and may not want to start all over again with standard, off-the-shelf software. Therefore, before deciding to embrace e-supply chains, a firm needs to clearly understand its own automation needs and different potential options for creating supply chains including their benefits and challenges. Only then a firm should select the supply chain option that it can successfully handle. Yet, very little effort has gone into understanding how different approaches to creating supply chains are suitable for different supply chain requirements. Considering the importance of the above issues for a large number of firms that will undertake e-supply chain implementation in the near future, the objective of this article is to develop a framework that captures different approaches to e-supply chain creation.

To have a better understanding of the creation and implementation of e-supply chain systems and the role of factors affecting them, we draw on research in areas such as supply chain management, Web-based information systems, and inter-organizational information systems. In addition, we conducted many discussions with professionals and consultants who are involved in planning, creating, and implementing e-supply chain systems in a variety of companies. Relying on such "theories-in-use" of thoughtful practitioners is advocated as an appropriate and a desirable method for studying a phenomenon like e-supply chains that is relatively new, and thereby, lacking in systematic and rigorous research (Cooper, 1995; Eisenhardt, 1989). In terms of actual implementation, we studied in detail two companies that recently installed e-supply chain systems, namely: a manufacturer of electronic products and a major distributor of industrial products.

The rest of the paper is organized as follows: in the next section, to highlight both the functionality and the complexity of integrated e-supply chain systems, we discuss in detail the system we studied at a manufacturer of electronic products, which is a highly integrated e-supply chain system. Then we identify the challenges associated with the creation and implementation of such a highly integrated e-supply chain. We next discuss the e-supply chain arrangement at a distributor of industrial products, which is only a partially integrated system. Here we examine how a firm that chooses a partially integrated supply chain can reduce the extent of challenges and thus make supply chain implementation more easily manageable. Thereafter, based on the knowledge that emerged from actual implementations that we studied and from discussions with experts, we develop the framework that identifies various approaches to creating e-supply chains. Finally, we discuss the managerial and research implications of our study.

2. E-supply chain systems

2.1. Highly e-integrated e-supply chain system at a manufacturer of electronics products

The electronic product manufacturer, referred to as the OEM (some of the details have been disguised to maintain confidentiality) has fairly complex internal and external operations. The company has many suppliers spread all over the world that supply a large variety of parts and components. These parts and components are used to produce a wide range of sophisticated electronic products for different market segments. The company was facing pressure from some of its competitors. For example, one major competitor had substantially lowered the inventory in its operations through an e-supply chain system. The competitor also provided better customer service by allowing customers to customize and track their orders over the Web. In order to effectively respond to such competitive challenges, the OEM felt that it needed to install an integrated Web-based supply chain system that would efficiently and effectively link-up its complex operations.

2.1.1. Information systems architecture

The OEM and several of its potential supply chain partners were in the process of integrating internal systems through Enterprise Resource Planning (ERP) software R/3 from SAP. For demand planning and forecasting the OEM used i2's Rhythm software. The customer relationship management (CRM) component was a custom written software that ran on a mini-computer. Integrated Web-based packages like mySAP were not considered because of the heavy investment in fairly sophisticated existing systems that worked fine for the OEM. Since scrapping the existing

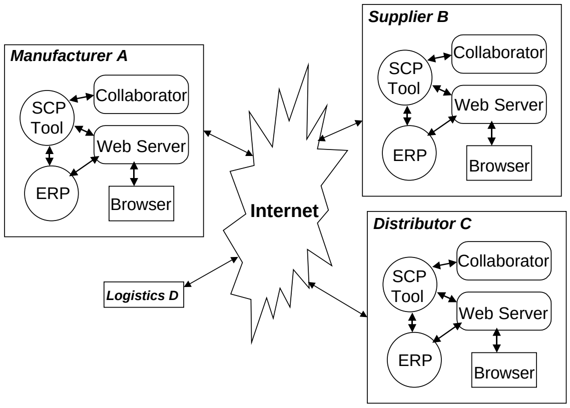

Fig. 1. Schematic of the highly integrated supply chain system.

systems would have been costly and would have unnecessarily disrupted the company's operations, the OEM felt that it would be better off by building the required functionality on top of its existing systems.

The system described here focuses on three major players: the manufacturer A (or the OEM), supplier B, and distributor C (Fig. 1). While the OEM had many other distributors and suppliers of components required in the assembly of its products, for simplicity those distributors and suppliers are not shown to be a part of the supply chain system described here. Also included are the logistics and warehousing facility called "logistics D."

While all three parties were integrating internal operations through standard ERP packages, a major system development effort was needed in the area of external connectivity so that the three companies could undertake joint demand planning, execute their plans in real-time, and handle exceptional situations quickly. Specifically, the system building effort focused on linking each party's ERP systems (i.e., SAP R/3) and the supply chain planning system (i.e., Rhythm from i2) to a Web server via Internet protocols. In addition, each party had a "Collaborator", which is a cooperative planning tool that helped participating firms in the supply chain to jointly arrive at production figures. A powerful Web server allowed connectivity to all the major databases and supported the three major multiple object component architectures CORBA, Enterprise JavaBeans, and Microsoft's Component Object Model (the three major standards that help achieve inter-operability between application programs and data on different platforms and locations). The Web server talked to the SCP system (Rhythm) and the ERP software (SAP R/3) via a custom written interface. The entire system was very complex as it required real-time integration of data from systems that were themselves complex. Further, since the integration was achieved through custom written code, writing such code required considerable effort.

2.1.2. Illustrative major tasks

We illustrate the complexity involved in creating and implementing the integrated e-supply chain system with the help of two illustrative major tasks that the system performed. Each one of these tasks was geared towards achieving competitive advantage by way of reducing inventory in the chain, avoiding delays, and providing better customer service. The two tasks are:

(1) cooperative planning among various members of the supply chain and (2) responding to customer query (Simchi-Levi, Kaminsky, & Simchi-Levi, 2000; Hutt & Speh, 2001).

2.1.2.1. Cooperative planning. A key element of the cooperative planning and forecasting mechanism is a meta supply chain model (see Fig. 2). For the three parties in the system, this meta model contains their tactical planning models, which are created by the parties themselves. The tactical planning model for any party consists of information that is specific to its situation. For example, information for supplier B contained details such as its capacity constraints, time required to switch production from one product/component to another, etc. Such information about the supplier is used by other partners (manufacturer A and distributor C) during the process of cooperative planning. The OEM might use this information to decide how many suppliers it will need to fulfill its expected demand or to evaluate how soon it can service a special order from a customer. If the situation with any of the parties' changes, since they are all interconnected, the revised information could be communicated in real-time to the systems of other parties to enable them to alter their respective plans. Suppose there was disruption in one of the supplier's plants. In an integrated e-supply chain system, such a disruption will be incorporated in the OEMs production schedules instantaneously. Although not explicitly shown in the above figure, logistics D was also integrated in the system and could tap into the meta model to plan their shipping container requirements synchronously with the OEMs production schedules. The meta supply chain model resided on a common Web application server.

From a technical perspective, implementation of the Web-based meta-model was a very complex task as a number of interfaces needed to be created for the data residing in the partners'

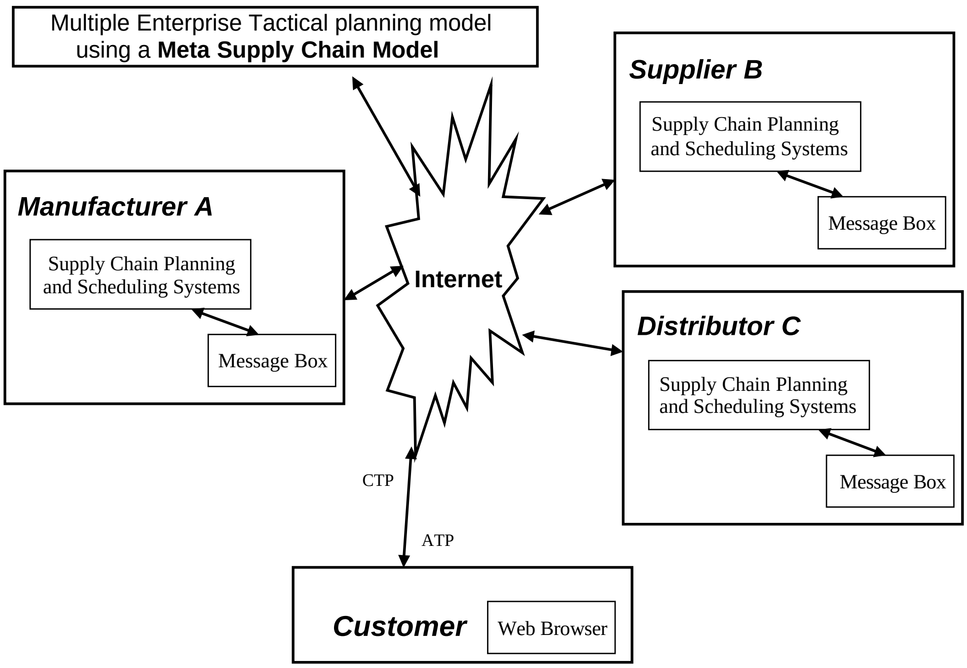

Fig. 2. Cooperative planning in highly integrated supply chain.

systems (i.e., SAP R/3 and Rhythm from i2). Creating a Web interface for data from SAPs R/3 system has been recognized to be a highly complex endeavor (Delphi Group, 1999). Further, due to customer service and competitive considerations, a need was felt to keep the time of dynamic Web pages served to customers in response to their queries at less than ten seconds. This added to the complexity of design due to native inefficiency of porting R/3 data over the Web. The problem was resolved by replicating R/3 data to a separate Oracle server.

2.1.2.2. Responding to customer query. Yet another critical task that an integrated supply chain performs is to automatically handle customer queries and orders on the Web. Let us say an institutional customer logs on to distributor C's Web page and requests a quote for 50 units of one of its latest products to be delivered on a given date. The system at C would process the request and ascertain the number of products in its stock (say 5). The request is further passed on to manufacturer A's SCP system as a capable-to-promise (CTP) query, which is the process of finding out whether the OEM is capable of supplying the product in the quantity demanded and meet the delivery and other related requirements of the customer. For this purpose, the OEMs SCP system would check its own finished product inventory (which is 10) and calculate the additional number of products required to be assembled (i.e., 35). The OEMs system then generates a bill of material (BOM) and queries the supplier's system as well (to check for component inventory and production schedule) and calculates various lead times required to assemble the remaining 35 products. Delivery times required by logistics D are also taken into account and the manufacturer's SCP system determines whether or not customer requirements can be met by the required date. If yes, then the system calculates a unit price based upon the customer profile that stores his/her payment terms, payment history, rebate offers and discount entitlements and quotes a price to the customer. Depending upon the customer's destination, freight is also calculated. All these transactions take place in real time over the Web through dynamically generated Web pages served to the customer over a secured server by distributor C.

After receiving customer's confirmation to purchase 50 products at the price quoted, the system starts the scheduling for manufacturing (as per the master plan), assembly, and procurement operations at A. At this stage, the CTP query is translated into an available to promise (ATP) arrangement, whereby products arrive just in time as promised to the customer.

The above integrated e-supply chain system helps the OEM, the supplier and the distributor to keep the least inventory on their shelves thereby resulting in huge benefits in terms of saving inventory carrying cost and obsolescence and at the same time provide better customer service. However, such a complex system created numerous challenges during its implementation. Without effectively overcoming such challenges, the success of the system would have been jeopardized.

2.2. Implementation challenges in a highly integrated supply chain

Many studies have highlighted numerous problems faced by a firm in adopting complex systems like ERP for internal operations (Davenport, 1998, 2000; Nash, 2000; Wilder & Davis, 1998; Weston, 1997; Zeitz, 1996). Similarly, the literature on inter-organizational systems has discussed the problems associated with the implementation of EDI systems that are largely limited to one-to-one relationships (Grover, 1993; Premkumar & Ramamurthy, 1995; Premkumar, Ramamurthy, & Nilakanta, 1994; Munson, Rosenblatt, & Rosenblatt, 1999; Hart & Saunders, 1997; Iacovou, Benbasat, & Dexter, 1995). But we found that the challenges involved in implementing integrated e-supply chains are bigger than the problems faced by an organization trying to adopt internal systems (like ERP) or inter-organizational systems (like EDI). Integrated e-supply chain systems are like enterprise resource planning systems of an extended enterprise in which diverse organizations need to work together as different departments of a single enterprise (Brock, 2001). We classify challenges that the electronics manufacturer and other organizations that implement highly integrated e-supply chain system face in the implementation process into two categories: challenges that are *internal* to the organizations and those that are *external* to them.

2.2.1. Internal challenges

Organizations invariably require considerable resources to implement highly integrated e-supply chain systems. Most of the software packages for creating e-supply chain systems are quite expensive and require several powerful computers, database systems, and local and wide-area communications links, which also require a large amount of investment (Wagner, 2001). Further, a good deal of investment is needed in making the e-supply chain system secure. It is particularly expensive to secure highly integrated e-supply chain systems because in such systems: (a) public Internet is used to transport data, (b) many more partners than in traditional EDI systems are usually involved, and (c) data exchanged tends to be highly sensitive. Thus, the electronics product manufacturer that implemented a highly integrated supply chain system had to expend financial resources that exceeded the expenses on many other information systems it had installed thus far.

Further, organizations that implement integrated e-supply chain systems need to have highly sophisticated technology infrastructure in place. The IS literature has discussed how organizations get overwhelmed by the technology infrastructure needed for implementing a complex system like ERP (Davenport, 1998, 2000; Nash, 2000; Wilder & Davis, 1998; Weston, 1997; Zeitz, 1996), but the infrastructure needs of a sophisticated and highly integrated e-supply chain system are even higher. For example, the electronics product manufacturer not only grappled with the problem of installing, configuring, customizing, and troubleshooting an ERP package, but also with creating linkages between several complex packages like ERP, supply chain planning, supply chain execution, and CRM systems. On top of that, the organization faced the additional challenge of porting data between the OEM and partner systems over a Web interface.

Also, if firms have some legacy systems that need to be integrated with the e-supply chain solution, they face additional challenges. For example, the electronics product manufacturer had its CRM software on a minicomputer whose integration with the e-supply chain system would have required considerable effort and time. In fact, in view of such challenges, the electronics product manufacturer decided not to integrate the CRM data with the rest of the e-supply chain system in the initial stages, even though this meant living with a sub-optimal system for sometime.

In addition, it repeatedly emerged that implementing an integrated e-supply chain system required a higher order of business process redesign than any other information system. This is so because with these systems, not only do internal business processes need to be integrated, but also these processes should work synchronously with those of external partners as well. The e-supply chain system thus not only changes the way in which an organization works internally but also how it works with its business partners. For instance, in the electronics product manufacturer's case, the system affected the demand planning process of a number of organizations, as well as the production planning process of the suppliers. For just the demand planning functionality to work effectively, many intra- and inter-organizational processes needed to be changed. Considering that an integrated e-supply chain system affected numerous other internal and inter-organizational processes (e.g. the procurement, manufacturing, and competitive bidding processes), the task of business process redesign was indeed significant.

Also, given that integrated e-supply chain systems introduce more changes than just ERP or EDI, considerably more organizational resistance arises during the implementation of such systems. Senior management has to be involved and needs to devote considerable amount of time for such systems to succeed. Therefore, before a firm creates an integrated e-supply chain, its senior managers have to carefully assess if they have the necessary commitment, time, and ability to manage a major change effort in the firm.

2.2.2. External challenges

Challenges related to bringing supply chain partners on-board and making them a part of the extended enterprise system are as important as the challenges firms faced internally. The literature on inter-organizational systems also discusses the importance of business partners in the successful adoption of such systems. For example, the extant literature suggests that a high level of mutual trust is needed for business partners to be willing to adopt electronic data interchange (Munson et al., 1999; Hart & Saunders, 1997; Grover, 1993; Premkumar, Ramamurthy, & Nilakanta, 1994; Premkumar et al., 1995). In the case of integrated e-supply chain implementation, the need for mutual trust gets amplified because the relationship between business partners needs to be much deeper. This is so because such systems integrate strategies of the participating firms. Managing such strategic inter-dependencies between chain partners is a major challenge as it opens participating firms to new levels of vulnerabilities. For example, in the case of the electronics manufacturer, for cooperative planning to work, suppliers needed to share their confidential data (such as production data and capacity constraints) with the OEM and felt vulnerable that the OEM could misuse that data to its advantage.

While some business partners agreed to become a part of the system for their own benefit, others were reluctant in adopting e-supply chain systems due to resource, technical, relationship (trust and vulnerability) issues, or simply due to a resistance to change to a new way of doing things. In such a case, the OEMs power over its partners played a major role. For example, even though some business partners of the electronics manufacturer were hesitant to invest in a sophisticated e-supply chain system at their end, because of the OEMs dominant position in the marketplace, they showed little open resistance and agreed to invest in the cooperative planning system and to redesign their business processes to fit the system. This issue of power between the OEM and suppliers has been discussed in inter-organizational information systems literature in the context of EDI adoption (Munson et al., 1999; Hart & Saunders, 1997; Grover, 1993; Premkumar, Ramamurthy, & Nilakanta, 1994; Premkumar et al., 1995). But since integrated e-supply chain system adoption requires a large commitment of resources and makes the partners more vulnerable, the power needed to get partners to comply is of a higher order.

In a related manner, to implement an integrated e-supply chain system the partners need large resources and a strong information technology infrastructure, somewhat comparable to that of the OEM. Further, if the required functionality needs to be built on top of the partner's existing information systems, there is a need for considerable amount of IT expertise for creating the necessary interfaces between diverse systems. Finding such expertise in some partner organizations proves to be quite difficult, particularly if they are small (Munson et al., 1999; Hart & Saunders, 1997; Grover, 1993; Premkumar, Ramamurthy, & Nilakanta, 1994; Premkumar et al., 1995). For example, in the electronics manufacturer's case, a supplier neither had extensive computerization of their operations nor adequate technical expertise, which affected the development of a highly integrated e-supply chain system. The supplier used the OEMs demand planner to generate its own production plans. Although such a compromise arrangement was acceptable in the short term, it limited the speed and responsiveness of the system.

Thus, there are major internal and external challenges involved in creating a highly integrated e-supply chain system. Obviously, not many organizations have the resources, technical infrastructure, commitment, power over their partners, or resourceful chain partners that are needed for the implementation of such complex systems. Unless senior managers assess their organization's ability to overcome the above challenges before implementing integrated e-supply chain systems, they will soon find themselves overwhelmed with problems and setbacks that will hinder a satisfactory implementation of the system. A compromised implementation will create operational problems and frustration within their own organization as well as in the supply chain.

However, if firms do not aim for a highly integrated e-supply chain, they can minimize the challenges they encounter during the process of implementation. As such, they do not need the massive financial, managerial, and organizational resources that are required for the implementation of an integrated e-supply chain. By scaling down the scope of e-supply chain integration, these firms can also reduce the risk of failure. We illustrate below how a large distributor of industrial products implemented a partially integrated e-supply chain system and thus reduced many of the challenges it faced.

2.3. Partially integrated e-supply chain system at the distributor of industrial products

This major distributor of industrial products operates throughout the country via its network of a few warehouses and many branch offices (some information has been disguised to maintain confidentiality). The operations of the company are backed by a logistics network that spans all its warehouses and branch offices (see Fig. 3). Furthermore, the company handles an exceedingly large number of stock keeping units (SKUs) and has different stocking policies for items depending on the frequency of use. For example, frequently demanded items are stocked at all the branches of the distributor. These items are procured from hundreds of different suppliers, consolidated at a few consolidation points, and shipped directly to branches all over the country. Items required by customers less than 100 times a year are procured from the suppliers, stored at a central warehouse, then shipped to customers from there. The distribution centers either ship them directly to customers or to the branch offices of the company for pick-up by customers. The company also makes arrangements for a few of its items to be shipped directly from the suppliers to the customers. Customers can place their orders through telephone, mail, fax, or by direct walk-in. After the popularity of Web-based ordering, the company decided to open another channel for customers to place their orders: through the Web.

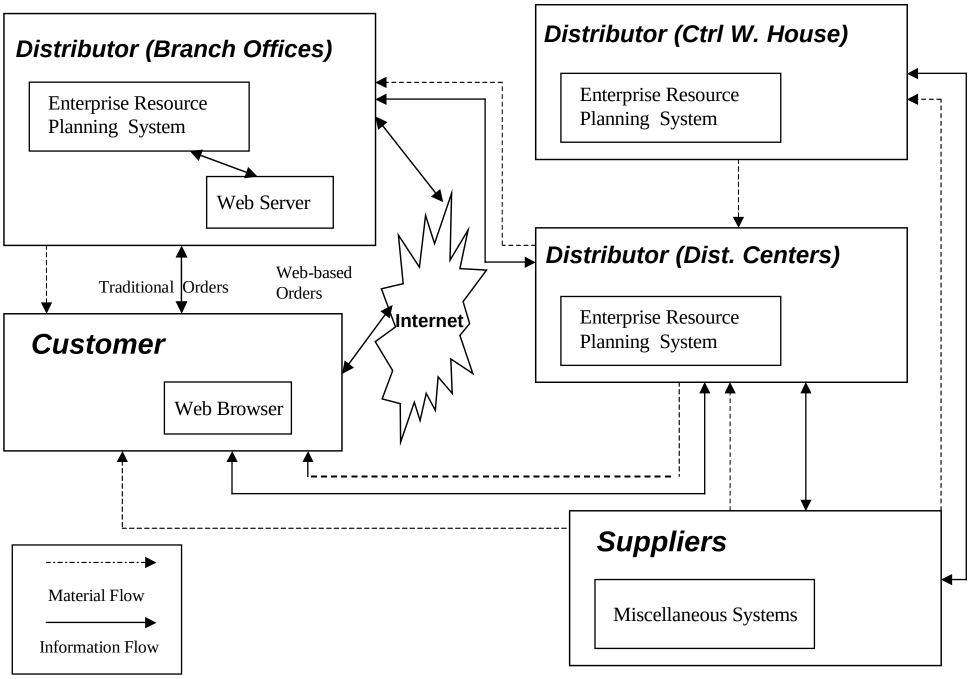

Fig. 3. Order fulfillment process in partially integrated supply chain.

The above factors, namely the wide geographic spread of the company's operations, the number of items it sells, and different stocking policies for items based on demand, make the internal operations of the company exceedingly complex. Due to the involvement of a large number of customers and suppliers, the company also has equally complex external operations. Both the internal and external operations are very important for the success of the company. For example, it is critical for the firm to maintain high service levels, i.e., to make available to its customers the products it lists in its catalog without any errors in the order fulfillment process and in a timely manner. To do so the firm has to ensure that customer orders are processed quickly and products from various suppliers are procured in a prompt manner and stocked adequately at various points in the distribution process. Furthermore, all these activities need to be executed with an eye on efficiency and costs.

Since the company continuously works to improve the efficiency and effectiveness of its supply chain, it felt a need to reduce the inefficiencies in its internal operations and in its dealings with customers. For instance, it wanted to make it easier for customers to place orders, streamline internal ordering (e.g., between branches and warehouses), and keep better track of inventory at various facilities. As such, the firm decided to implement a Web-based supply chain system. However, unlike the electronics manufacturer, this company did not create all at once a highly integrated supply chain. It decided to focus on its internal operations and the linkages with customers in the first phase and the task of creating linkages with its suppliers was postponed to the second phase.

In an attempt to streamline their internal processes and to offer better customer service, the company initiated two major information systems projects. It installed an ERP package for order processing and created a Web interface for customers to search through its electronic catalog and place orders on-line. The internal systems of the company had a number of legacy components for critical operations like inventory control, management, and forecasting. The company integrated its enterprise-wide order processing through an ERP system and created internal linkages between its legacy and ERP systems as well as between the Web-based ordering system and the ERP system. However, it did not install inventory control, forecasting, and procurement modules of the ERP package. Instead, the company integrated their legacy inventory systems with the ERP system on a selective basis. Under the new system, customers could search the electronic catalog of the distributor over the Web, check availability and prices of products, and place their orders on-line. However, unlike the electronics manufacturer, the system did not search the business partners' databases for availability of products, nor did it calculate lead times for making the product available to the customer.

2.4. Implementation challenges in a partially integrated e-supply chain

The company faced a number of challenges in implementing its IT initiatives. Besides technical challenges in implementing a corporate-wide ERP system, there were numerous challenges in integrating legacy data with the ERP system as well as in creating Web linkages for customer orders with the ERP system. The company needed to redesign a number of business processes for the ERP system to work successfully and also needed to overcome organizational inertia to the new system. However, senior management's active support of the project helped overcome many of the above challenges. The company also needed considerable financial resources for implementing a project of this size. Because of top management support, financial resources required for the above two projects were made available and the projects were completed successfully on schedule.

Since the company first focused only on internal operations, the range of challenges it faced became more manageable. It did not have to put energy and effort into integrating a variety of suppliers into the supply chain system. Considering the large number of suppliers the company has, it would have been particularly challenging to ensure that these suppliers create the necessary IT infrastructure in their organizations, agree to make available a lot of sensitive data about their operations to others in the supply chain, and redesign business processes to match the demands of the supply chain. Further, given that in an externally oriented system a great deal of confidential data would have flowed over the public internet, the company would have had to invest large resources in creating a very secure Web-based supply chain system. A phased creation of the supply chain system helped the company to focus its resources in making this internal-oriented supply chain system successful.

The system has helped the company streamline its internal operations, improve customer service, and cut down the paper trail. In addition, the project led to savings due to considerably superior inventory management under the new system. The company also lowered ordering costs as orders received over the Web cost substantially less than through the traditional channel.

Thus, the study of the industrial distributor's system suggests that at times it is better for a company to not opt for systems that will simultaneously integrate all of its internal and external operations. Instead, a company can move towards a totally integrated system in phases and thereby make the implementation challenges manageable. While vendors of systems like mySAP, Oracle11i, i2, and Manugistics might create an impression that the way to automate a firm's supply chain is through the use of sophisticated integrated software, not all organizations need such complex systems. In other words, there is hope for smaller and medium-sized organizations that may not have the capacity to undertake a large-scale integration of their supply chain through the Web. However, there is very little literature that can help managers arrive at an approach for creating e-supply chains that is suitable for their context. What is needed is a framework that goes beyond the simplistic *highly integrated* or *very low integration* scenario and shows how managers have multiple alternative approaches to creating and implementing e-supply chain systems. In the next section, we develop such a framework.

3. Classifying approaches to e-supply chain implementation

During our study of the above two supply chain implementations and discussions with various managers, it has emerged that the issue of e-supply chain implementation can be studied along two important dimensions: complexity of a firm's operations and the firm's ability to integrate their external business partners into their e-supply chain. A firm's operations can be complex due to several reasons including when its operations involve numerous activities and transactions. This complexity can be the characteristic of a firm's internal operations, operations with its external partners, or both its internal and external operations. If operations are not complex, the need to integrate them through a sophisticated supply chain system is reduced. Such a determination of the suitable level of system integration has been considered a critical issue in the IS literature as well (Allen & Boyton, 1991; Yakhou & Rahali, 1992; King, 1984; Mukhopadhyay, 1993; Premkumar et al., 1995, 1994).

A firm's ability to integrate its external partners into the supply chain refers to its ability to persuade the partners to participate in the chain and create necessary infrastructure and redesign business processes to match the supply chain system being implemented by the firm. Two main factors that will facilitate integrating external partners in a firm's supply chain are: trust between the parties and the power the firm has over the partners. Obviously, some firms will be more successful than others in integrating external partners into their systems and that will have an impact on the type of supply chain systems that can be successfully installed with these partners. This ability to persuade business partners to integrate their information systems with those of a firm has been considered important in the IS literature (Munson et al., 1999; Hart & Saunders, 1997; Grover, 1993; Premkumar, Ramamurthy, & Nilakanta, 1994; Premkumar et al., 1995).

Thus, we develop the supply chain implementation framework by taking into account the above dimensions. As discussed above, the first dimension, *the complexity of a firm's operations* can apply to the firm's internal operations, external operations, or both (i.e., it has three levels). The second dimension, *the firm's ability to integrate partners into the supply chain* can be either high or low (i.e., it exists at two levels). Hence, we have a 3×2 scheme for classifying approaches to e-supply chain implementation. It is pertinent to note that in the situation where a firm's operations are complex only internally, it is not so important for the firm to integrate external partners into the supply chain. We, therefore, fold the two cells of our classification corresponding to the

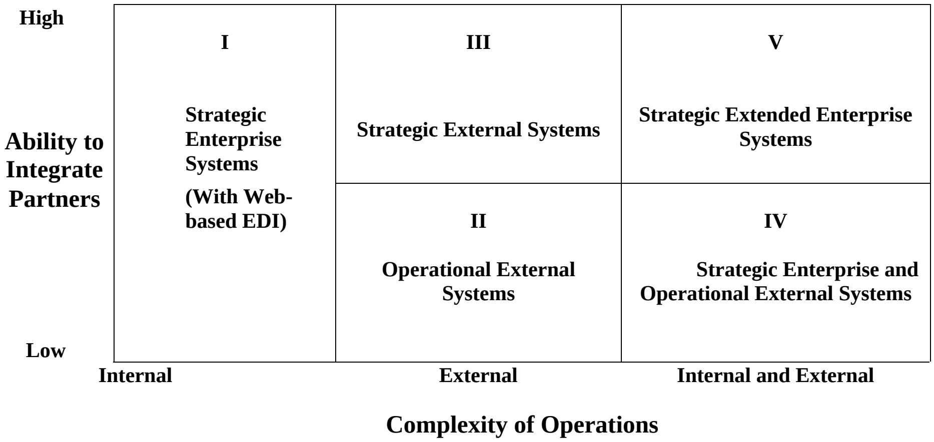

Fig. 4. A framework for supply chain implementation.

complexity of internal operations into one. This reduces the number of distinct e-supply chain implementation approaches to five, as shown in Fig. 4.

Besides the above issues, managers need to decide whether to build the required e-supply chain functionality on top of their existing systems or to buy an off-the-shelf software package to automate and integrate their e-supply chain. While integrating existing information systems into the new supply chain arrangement can increase the technical complexity of the task, it reduces some of the challenges and huge investment involved in installing new systems. For example, such an approach requires smaller new investment, reduced changes in business processes, fewer changes in procedures, and a lesser need to train employees in the use of a completely new system. In fact, firms that have already installed certain software may want to buy additional components of the best-of-the-breed supply chain-related software from vendors and customize and integrate them into their existing infrastructure (Simchi-Levi et al., 2000). Therefore, while deciding what approach to e-supply chain creation is suitable for it, another important decision before a firm is whether to build a supply chain system over its existing IT infrastructure or to buy an off-the-shelf software package. We take into account this buy-versus-build option while discussing each of the five approaches included in our framework. This buy versus build decision is considered to be a major issue in system development in the IS literature (Bakersville & Stage, 1996; Arthur, 1992; Lacity et al., 1996; Lacity & Hirschheim, 1993).

3.1. Strategic enterprise systems (Cell I)

A firm that falls in this cell has operations that are mostly internally complex, and, therefore, has a high need for internal integration but its need for external integration is low. This may be so, for example, because the firm has complex manufacturing operations, but most of the components and sub-assemblies are made in-house. Complex manufacturing operations can involve multiple manufacturing facilities and assembly lines and numerous storage points for raw material, work-in-process, and finished goods inventory. The firm will, thus have a high need for internal integration so as to ensure smooth flow of its operations, but since external partners do not play a critical role in the manufacture of the product or its distribution, the firm does not need to concern itself with integrating business partners with its e-supply chain system. Sometimes, this approach may also be chosen because the firm does not have enough resources to manage both high internal and external integration simultaneously and it believes that it can more easily or effectively handle internal integration.

Under this scenario, if the firm's investment in its legacy systems is small or if such systems have outlived their usefulness, the firm may want to buy and adapt a standard software package. A suitable strategy for such a firm will be to install strategic enterprise systems such as ERP systems. Since in this situation external linkages are less important, an appropriate e-supply chain strategy for the firm would be to share the output of its ERP system with external partners over a Web-based EDI linkage (Angeles, 2000). Complicated off-the-shelf packages for supply chain planning, execution, and logistics for integration with external partners will not be cost effective for such a firm.

In the above approach to e-supply chain implementation, the challenges that the firm encounters will be mostly internal to the organization. For example, fairly large amount of resources, a strong IT infrastructure for a strategic enterprise system, and a significant change management effort will be needed. Security issues will require attention, but not to a great extent because external integration is quite limited in such cases and primarily the internal data and networks need to be secured.

3.2. Operational external systems (Cell II)

A firm in this cell has operations that are mostly externally complex, and, therefore, it mainly needs external integration, while its need for internal integration is limited. This will be the case, for example, when the firm's products are such that a large number of components and sub-assemblies are provided by external partners, while the firm focuses largely on some limited in-house assembly. In such a situation, it is important for the firm to create sophisticated linkages with external partners in order to optimize its external value chain.

However, since the firm does not have a high ability to integrate business partners into a sophisticated e-supply chain system, instead of pursuing an e-supply chain system that is highly integrated externally, it should aim for a limited arrangement with its partners. Thus, an appropriate strategy for such a firm is likely to be that of creating operational external linkages in areas like procurement and logistics and thereafter, gradually expanding the supply chain functionality to more strategic functions like collaborative planning, forecasting, and replenishment, and integrated CRM. For example, the firm can purchase Ariba Buyer software for its procurement needs and customize it for its given situation (King, 2000). Similarly, a company can obtain Web-based logistics services from UPS or Internet-based logistics exchanges run by National Transportation Exchange (Rosencrance, 2000; Anonymous, 2000). However, some firms may already have certain valuable legacy procurement and logistics applications that they may be using for achieving integration with partners through traditional EDI. In such a case, instead of investing in new off-the-shelf applications and redesigning business processes for procurement and logistics to suit such software, the firm may simply want to provide a Web interface to these existing applications.

During the implementation of this strategy, challenges will be mainly related to external partners because changes in internal operations are minimal. The firm will be required to devote resources to redesign operational external processes jointly with its partners and to secure the supply chain data and network. But, since the data exchanged in the external systems is mainly operational in nature, the OEM-partner trust need not be not be as high as it has to be when the firm has highly integrated external linkages.

3.3. Strategic external systems (Cell III)

Similar to the previous cell, a firm in this cell has operations that are complex externally, and, therefore, may mainly need external integration with limited internal integration. However, this firm differs from the firm in the previous cell because it is able to more effectively integrate its external partners into the supply chain.

A firm falling in this cell is advised to seek supply chain integration with external partners in strategic areas like collaborative planning, forecasting, and replenishment, collaborative product design, and integrated CRM. Such a firm will benefit from strategic external systems like the ones available from suppliers like i2, Manugistics, etc. This option is particularly appropriate if the firm has made only marginal investment in legacy supply chain planning software or if its legacy supply chain planning software has run out of its useful life. These supply chain systems can, in turn, be linked with some standard database management software that may be sufficient to handle the firm's simple internal operations like inventory management and accounting. The firm needs to be conservative in its approach toward integration of the internal system, as high internal integration is not really needed in its operations. As such software packages like mySAP and Oracle11i that emphasize high internal and external integration may not be suitable for such firms.

However, if the firm already has some valuable installed IT infrastructure, it may follow a different approach to creating its supply chain solution. For example the firm may already have a system that it uses for demand planning. In that case, in order to create the e-supply chain system, the firm will need to create linkages between the existing demand planner and other internal systems as well as port the demand data over a Web interface for external connectivity. Such an exercise is likely to be a substantial system building effort on the part of the firm.

Main challenges in implementing systems corresponding with this cell will be to get the resources necessary for supply chain integration with external partners in strategic areas like collaborative planning, forecasting, and replenishment, and integrated CRM. The firm and its partners will also require technical sophistication of a fairly high order to implement such systems and to make them secure. Additionally, the organization will face the challenge of redesigning processes jointly with external partners in order to effectively implement such systems.

3.4. Strategic enterprise and operational external systems (Cell IV)

A firm in this cell has operations that are complex both internally and externally, and, therefore, has a strong need for internal as well as external integration. However, since this firm does not have a high ability to integrate its external partners into the supply chain, it needs to carefully think through its e-supply chain implementation strategy. While it may appear attractive to the firm to create sophisticated e-supply chain systems that integrate well with business partners' systems, in the absence of adequate partner integration, the firm's efforts may not bear much result and may be an unnecessary drain on its resources. An appropriate strategy for such a firm is likely to be to focus on integrating their internal systems and create external linkages in areas like procurement and logistics. It can defer expansion of the supply chain functionality to strategic functions like collaborative planning, forecasting, and replenishment, and integrated CRM.

If the firm does not have a strong existing IT infrastructure of value, the firm should consider the option of scrapping the existing systems and building this e-supply chain system from scratch. The firm in that case can create the requisite supply chain functionality by opting for some off-the-shelf strategic enterprise software that enables integration of internal processes, and by creating operational linkages for procurement and logistics. On the other hand, if the existing information systems of the firm are adequately serving its needs for internal integration and the firm also has some applications in place for procurement and logistics, the systems building option for the firm could be to integrate procurement and logistics operations with the application for internal operations and establish linkages over a web interface with external partners.

Major challenges in implementing systems corresponding with this cell will be related to implementing a strategic enterprise system and integrating its existing legacy systems with it. Thus, it will need considerable amount of resources, technical expertise, and internal process redesign. The firm will also be required to devote resources to redesigning operational external processes jointly with its partners and to securing data and the network. However, considering the fact that the data exchanged is not likely to be so strategic in nature, a high degree of trust with the business partners is not very critical for implementing the external linkage.

3.5. Strategic extended enterprise systems (Cell V)

Similar to the firms in the previous cell, a firm that falls in this cell has operations that are complex both internally and externally, and, therefore, it needs to aim for an e-supply chain solution that incorporates both internal and external integration. Moreover, this firm has high ability to integrate business partners into a sophisticated e-supply chain system.

The firm will have two options for integrating its internal operations and supply chain system with those of its business partners: either through an off-the-shelf integrated software package or through a customized solution that integrates best-of-the-breed software packages and ports its output over a Web interface, as done by the electronics manufacturer. Two major initiatives in the off-the-shelf integrated category come from SAP (called mySAP) and Oracle (called Oracle11i) (D'Amico, 1999; Menezes, 1999; Wagner, 2001). Both mySAP and Oracle 11i are relatively new systems that have not been widely installed. In fact, problems of compatibility with some existing applications that Oracle11i is reported to have, seem to have made some companies hesitant in implementing this software (Wagner, 2001). Thus, the firm's IT experts may have to get deeply involved in the implementation process of these complex software packages and be ready to trouble-shoot some unforeseen problems. On the positive side, both SAP and Oracle have been in the market with their enterprise integration software for a long time and have the necessary expertise to facilitate the successful implementation of their systems.

The second scenario might be that the firm has invested already in some type of systems, e.g., internal connectivity software like ERP or supply chain software from vendors like i2 and Manugistics. Thus, it may not wish to scrap its investment in existing software solutions and start afresh with a solution like mySAP or Oracle 11i. In fact, it might want to retain the best-of-the-breed functionality offered by software from vendors like SAP, i2, Manugistics and Siebel instead of committing itself to a single vendor software like mySAP or Oracle 11i (Raman & Singh, 1998; Simchi-Levi et al., 2000). In such a situation, the firm is faced with the task of integrating various systems at its end with those of its supply chain partners through a Web interface. This is indeed a complicated exercise and there are likely to be several implementation difficulties.

Major challenges in implementing these supply chain systems will be those of integrating multiple systems within the firm as well as integrating them with business partners' systems. Considerable amount of financial resources and technical expertise will be required to make such integration possible and to secure the data and the network. The firm and its business partners will also be required to undertake substantial process redesign necessary for supply chain integration in strategic areas like collaborative planning, forecasting, and replenishment, and integrated CRM.

4. Conclusions and discussion

There is a great deal of excitement in the marketplace about how various supply chain software packages can integrate the operations of a firm's supply chain and improve its efficiency and competitiveness. However, in this excitement, it is often overlooked that creation and implementation of integrated supply chains requires overcoming tremendous challenges. Further, a standard solution cannot fit all types of supply chains because different chains have different requirements, and many firms may not want to use such off-the-shelf solutions since they already have some components of the supply chain system in place. Therefore, to help firms understand different approaches to creating supply chains from among which they can pick the approach they can successfully implement, we have developed a framework in this paper that captures various approaches.

4.1. Research implications

From a research perspective, our work should be considered a beginning in the important yet under-researched area of e-supply chains. Our study points to several areas for future research. For example, we have highlighted that integrated e-supply chain systems substantially impact inter-organizational relationships. One key challenge facing organizations implementing such systems will be the management of change in a highly integrated supply chain. However, most of the change management literature in the areas of organization theory and management information systems is mainly focused on change-related issues within an organization. While there exists some work on change management issues involved in EDI implementation, it does not capture the dynamics and complexities of simultaneous internal and external change in a complex inter-organizational arrangement like an integrated supply chain. For example, both an OEM and its partners' organizations have to think like an integrated chain and make decisions that are optimal from the perspective of the chain. Usually the job of introducing chain-wide change in the mind-set will fall on the OEM. But we do not know whether the change management strategies that can be used to introduce change within an organization will work when introducing change in some other organization. Thus, there is a need to revisit intra-organizational change management theories to ascertain if they will as effectively apply to inter-organizational or supply chain-wide change.

Another area of research would concern the relationship of e-supply chains to B2B exchanges. As of now B2B exchanges mostly provide transactional services like buying and selling of direct and indirect material through market-making mechanisms like catalogs, auctions, and reverse auctions. However, B2B exchanges that provide services like integration of the exchange data and information flows with back-end systems are emerging. For example, the auto exchange Covisint offers a service known as SupplyConnect that enables integrated e-supply chain functionality. Similarly, the retail industry exchange, Transora, offers to its members a collaborative planning and forecasting service, similar to the one described for the electronics manufacturer of our study. While firms may consider implementing systems discussed in this paper for automating and integrating their supply chains, the use of B2B exchanges for supply chain integration will be viewed as more risky because it involves putting a supply chain's confidential data on a third party's system. However, we know little about the conditions under which firms will be willing to adopt such an exchange-based system for supply chain integration rather than an internal Web-based system.

Recently, a new concept of peer-to-peer exchanges has emerged (McAfee, 2000). These exchanges will rely on search and integration technologies similar to popular music exchange sites like Napster and Gnutella and will enable organizations to flexibly search for suppliers without even having to go through an exchange. A research issue that peer-to-peer inter-business integration technology will open up is: for what type of transactions and conditions will such peer-to-peer mechanisms be more beneficial than e-supply chain systems discussed in this paper?

4.2. Managerial implications

Our study advises managers that before jumping on the supply chain bandwagon, they should assess the level of integration needed in their e-supply chain. If their operations are such that they do not need very tight and deep integration with their business partners, then they need not invest in elaborate strategic external systems that will enable collaborative planning, forecasting, and replenishment, and integrated CRM. Likewise, if an organization's products do not require tight integration within organizational functions and processes, an elaborate strategic enterprise system (e.g., an ERP system) will not be really required. Firms are also advised to assess their installed IT infrastructure and then decide whether to invest in an off-the-shelf software package that will enable their e-supply chain system, or, build the requisite functionality on top of their existing information systems.

Additionally, it will be prudent for managers to assess the challenges involved in the creation of integrated supply chains and carefully weigh whether they should opt for implementing a highly integrated solution in one go or gradually phase it in (i.e., by first embracing only internal or external integration). For example, from the perspective of their internal operations, managers are advised to be aware of the substantial redesign of business processes that integrated e-supply chain systems will require in order to be successful. The key lesson for managers here is that many of the processes will need to be redesigned jointly with business partners, who may not either see things the firm's way, or may lack the management skills to enforce such a change in their own organization. In a similar vein, managers are advised that integrated e-supply chain systems are likely to disrupt the current practices and organizational structures, thereby requiring a big change management effort. The additional challenge here is that similar change management initiatives need to take place in partner firms, over which a firm may have little or no control.

Finally, we have discussed the role of a firm's power over its partners to overcome some of the business partner related challenges. If the firm has a dominant position in the marketplace, similar to that of the electronics manufacturer, then they have the option of exercising power over business partners and making them adopt an integrated e-supply chain system. However, managers are advised to exercise caution in coercing business partners and alienating them in the process because in an integrated e-supply chain system, the key to success is mutual cooperation and inter-dependence. Similarly, although integrated e-supply chain systems open the prospect of reaching out directly to the end customers and bypassing the existing or off-line distribution channels, managers are advised to carefully evaluate the role of existing channels. At times the off-line channels, though more expensive and inefficient than direct marketing to end customers, can bring in competitive advantage to organizations by way of well established dealer networks and customer trust and loyalty that retailers command.

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