Chapter IX

Costs and Benefits in Supply Chain Collaboration[1]

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Abstract

Recent advances in supply chain management information systems (SCM IS) have enabled firms to more fully collaborate with their supply chain partners — driving out costs while increasing responsiveness to market demands. This chapter examines various types of SCM IS — from traditional EDI systems to more recent Web-services-based e-business applications. It argues that the approach best suited for an organization depends in part on the degree of integration between the partners, the complexity of the business processes, and the number of partners involved. A model is presented for analyzing the costs and benefits that can be expected from each type of SCM IS. The model enables researchers and practitioners to better understand the differences among SCM IS and thus can help reduce the risks of implementing these valuable yet complex information systems.

Introduction

For several decades, interorganizational information systems (IOS) have enabled the buyers and suppliers in a supply chain to exchange information electronically. By reducing the errors, costs, and time associated with the manual reentry of data, Electronic Data Interchange (EDI) technologies enable firms to reduce their transaction processing costs, cycle times, and inventory levels (Mukhopadhyay, Kekre, & Kalathur, 1995; O'Leary, 2000). However, the adoption of EDI systems limit trading partner flexibility, resulting in benefits often accruing to one partner at the expense of the other (H. G. Lee, Clark, & Tam, 1999). Furthermore, the usage of IOS has traditionally been limited to exchanging transactions rather than enabling the further benefits of supporting collaboration through the coordination of processes and information (Konsynski, 1996).

The recent innovations in more flexible Internet-based supply chain management information systems (SCM IS) promise to improve both the efficiency and agility of each of the partners in a supply chain (Green, 2001; Reddy, 2001a). Whether a firm implements an electronic marketplace, Internet EDI, extended enterprise resource planning (EERP), or other SCM IS, choosing the right approach is a risky undertaking given the number of factors that influence the total costs and benefits.

This chapter analyzes the SCM IS alternatives and presents a framework for understanding the expected costs and benefits of each type of IS. It begins with an overview of supply chain collaboration and its importance to many firms. It then describes the various SCM IS alternatives for supporting supply chain collaboration and introduces a framework for determining their expected costs and benefits. It concludes with an explanation of how firms can use the cost-benefit model described to implement SCM IS that are better aligned with their competitive strategies.

Supply Chain Collaboration

Collaboration is an approach to supply chain management (SCM) that moves beyond mere transactional exchanges to focus on joint planning, resource coordination, and process integration between buyers, suppliers, and other partners in a supply chain (Horvath, 2001; Kumar, 2001). Recent advances in electronic business practices are enabling firms to use collaborative commerce to drive out costs and increase return on assets in their supply chain, as well as increase their responsiveness to changing market demands (McLaren, Head, &

Yuan, 2002). However, supply chain collaboration itself is not a new concept and has had varying degrees of success in 1980s SCM initiatives such as Quick Response (QR) or even EDI implementations (Borck, 2001).

Researchers differ on how strictly they use the term "supply chain collaboration." Some emphasize that collaborative relationships are cooperative rather than adversarial or focused on price (Lamming, 1993). However, most business relationships are not truly collaborative and usually involve some imbalance of power that is wielded to the detriment of one of the partners (Bensaou, 1999). The presence of true collaboration often depends on who you are talking to — the buyer or the supplier! Other researchers use supply chain collaboration to refer to specific collaborative processes such as collaborative planning, forecasting, and replenishment (CPFR) or technologies such as electronic meeting rooms. However, like many practitioners, we prefer a more inclusive definition of supply chain collaboration as *"any kind of joint, coordinated effort between two parties in a supply chain to achieve a common goal"* (McLaren, 2002).

Similarly, some authors have felt that the term supply chain has a connotation that is limited to supplier processes and does not emphasize the customer or distribution processes involved. Thus, we have terms such as value chains (Porter, 1985), supply networks (Harland, Lamming, Zheng, & Johnsen, 2001), and business webs (Tapscott, Ticoll, & Lowy, 2000) used interchangeably with supply chain, though their usage is not always consistent. However, in today's demand-driven supply chains, the distinction between supply chains and demand chains is blurred and is dependent on perspective. In many cases, a web or network is a more accurate metaphor than a chain, though the distinction is not important to this paper, as collaboration still mainly occurs between only two partners at one time. Again, we use supply chain as it is most commonly used to include all the partners involved in delivering a good or service to a customer.

Businesses in the early part of the 20th century were often characterized as vertically integrated operations. Integrated operations like Ford Motor Company performed manufacturing, sourcing, warehousing, sales, and logistics functions "in-house." However, by the late 1900s, vertical integration had substantially disappeared and most organizations included external partners in their supply chain. Since these external partners (suppliers, transportation providers, retailers, etc.) are outside of the management control of an organization, supply chain management has traditionally involved each organization managing their portion of the supply chain and monitoring their partners to ensure they fulfill their contractual obligations (Ballou, 1999).

There can be numerous problems with this approach, the best known perhaps being the "bullwhip effect" (see *Figure 1*), where the effects of uncertainty in demand and lead times cause order sizes and lead times to be inflated the further up the supply chain and away from the end customer the orders for suppliers get. This leads to a greater amount of excess and often obsolete inventory throughout the supply chain, as extra inventory is required to protect against uncertainty and stock outs between each link in the chain. However, with increased management coordination of the supply chain and by making end-customer demand information readily available to the entire supply chain, the demand uncertainty along the chain and its resulting bullwhip effect can be reduced (H. L. Lee, Padmanabhan, & Whang, 1997b).

While supply chain management focuses on controlling the activities amongst the supply chain partners, supply chain integration focuses on improving the information flow between links in the chain, and supply chain optimization or coordination focuses on making decisions that reduce the information asymmetry and resulting excess inventory in the supply chain. If only the dominant partner drives supply chain optimization decisions, this can create an asymmetrical distribution of information, inventory, and ultimately bargaining power between the partners (Iacovou, Benbasat, & Dexter, 1995). In order to optimize the entire supply network instead of creating local optima in one or two partners, the organizations must make *joint* supply and demand decisions that create sustainable value for all involved. Hence, many organizations are increasingly developing strategic partnerships with their suppliers and customers and implementing supply chain collaboration initiatives in an effort to reduce waste in their procurement and order fulfillment processes (Porter, 1985).

As shown in *Figure 2*, operational-level applications of supply chain collaboration principles focus on exchanging and integrating information between partners using interorganizational information sharing techniques such as EDI or extended ERP as well as transaction cost reduction programs such as vendor-managed inventory (VMI). At the tactical level, programs such as collaborative planning, forecasting, and replenishment (CPFR), continuous replenishment (CRP), and sharing of point-of-sale (POS) demand information move beyond a

Figure 1. Information Distortion: The Bullwhip Effect (after Lee et al., 1997)

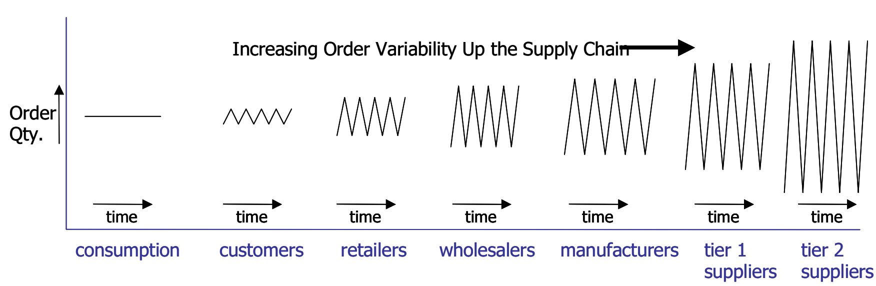
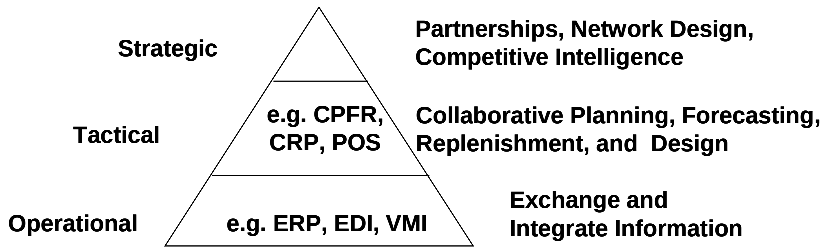


Figure 2. Example Supply Chain Collaboration Initiatives



focus on transactional efficiency and attempt to achieve further top and bottom line benefits through coordinating supply and demand (Barratt & Oliveira, 2001). Finally, strategic-level applications of supply chain collaboration involve the decisions about partnerships, network design, and gathering competitive intelligence in order to support such strategic decisions.

The common feature of every supply chain collaboration initiative is that it (ideally) involves the coordination of trading partner goals, decisions, processes, and performance management to achieve some shared benefit (Moncrieff & Stonich, 2001; Quinn, 1999). Effective supply chain coordination can eliminate excess inventory, reduce lead times, increase sales, and improve customer service (Anderson & Lee, 1999). Using some variation of EDI to exchange purchasing transactions electronically results in more timely and accurate orders with lower transaction costs (Mukhopadhyay et al., 1995; Seidmann & Sundararajan, 1998). Partners can then deliver products "just-in-time" without having to maintain costly inventory buffers "just-in-case."

However, merely exchanging transactions among trading partners more quickly and cheaply is no longer enough to maintain a competitive advantage for many firms. Instead, supply chain partners like retailer Wal-Mart and manufacturer Proctor & Gamble use more collaborative initiatives such as CPFR to better synchronize supply and demand, coordinate marketing efforts, and further eliminate waste in the supply chain (Koch, 2002). By jointly sharing supply and demand plans in addition to transactions, firms can further reduce the bullwhip effect while increasing their responsiveness to market demands and customer service (Mentzer, Foggin, & Golicic, 2000).

Furthermore, while operational-level inter-enterprise systems such as EDI systems often benefit customers much more than suppliers (H. G. Lee et al., 1999), systems that support tactical and strategic collaborative planning help ensure that the benefits of coordination are sustainable and experienced by all members of the chain, not just the customers. This shared value enhances the sustainability of the relationship, while equalizing the bargaining power of the partners (Seidmann & Sundararajan, 1998) and strengthening their level of trust (Karahannas & Jones, 1999).

In summary, the benefits of supply chain collaboration can include not only the reduction of waste in the supply chain, but also increased responsiveness, customer satisfaction, and competitiveness among all members of the partnership as the firm focuses on tactical and strategic applications of the principles (Mentzer et al., 2000). To support supply chain collaboration, IOS are required to handle the large volume of information that must be shared between the partners and to facilitate the coordination and management of the supply chain processes involved. In the following section, we describe the various SCM IS alternatives and introduce a framework for determining their expected costs and benefits.

Classifying Supply Chain Management Information Systems

There are many different types of supply chain IOS, such as EDI- or inter-enterprise application integration (IEAI)-based systems, electronic marketplaces, or even noncomputerized phone- or fax-based systems. Unfortunately, there are often confusion and inconsistencies among the terms used to classify a particular type of SCM IS. For example, for what Kaplan and Sawhney (2000) call an "e-hub," others use the terms "online public trading exchange" or "third-party electronic marketplace." To others, an e-hub is something different — an internal software platform for providing connectivity to trading partners (Stevens, 2001), something which other researchers call a "portal" (Reddy, 2001b). Similarly, using the term "portal" can lead to confusion unless one specifies whether it is a customer portal, supplier portal, or internal (corporate) portal and more importantly what capabilities it provides.

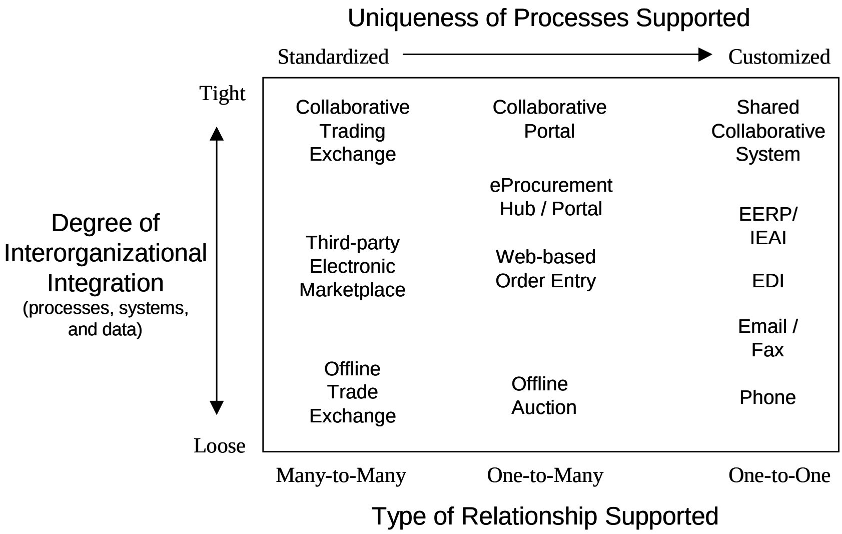
Adding to the confusion is the considerable overlap in the technologies used and capabilities provided by each type of SCM IS. Many firms adopt a portfolio of information and communication technologies (ICTs) for supporting their supply chain, which frequently contains a mix of EDI, ERP, and procurement solutions, and it is difficult to classify such hybrid systems as strictly one type or another (Dagenais & Gautschi, 2002). Nonetheless, we have tried to adopt the most widely used terms used in practice in describing SCM IS and will explain their key differences in the following.

SCM IS have varying capabilities for coordinating supply and demand information throughout a supply chain, which can reduce the bullwhip effect (H. L. Lee, Padmanabhan, & Whang, 1997a; van Hoek, 2001) and enable the benefits of more collaborative supply chain management (Horvath, 2001; Kumar, 2001; Peterson, 1999). One way of differentiating SCM IS is by looking at how information is coordinated between the supply chain partners. This can be accomplished through: sending messages from one firm's computers to another; interacting with another firm's computers; or through using a shared IOS that contains both firms' information. This distinction allows us to classify SCM IS roughly as:

- *message-based* systems that transmit information to partner applications using technologies such as fax, e-mail, EDI, or Extensible Markup Language (XML) messages;
- *electronic procurement* hubs, portals, or marketplaces that facilitate purchasing of goods or services from electronic catalogues, tenders, or auctions; and
- *shared collaborative* systems that include collaborative planning, forecasting, and replenishment capabilities in addition to electronic procurement functionality.

However, since there are still major differences between different types of SCM IS within each of these groupings, we will describe further ways of distinguishing between them. Other key differences between SCM IS are the type of trading relationships and processes they are designed for and the degree of interorganizational integration they support, as shown in *Figure 3*. An important attribute of the IS is the cardinality of the interorganizational relationships the system is designed to support (McLaren et al., 2002). In other words, is the system optimized for supporting one-to-one relationships, such as EDI, or many-to-many relationships, such as multiple suppliers and customers interacting in an electronic marketplace? Somewhere in between these extremes lie systems designed for one-to-many relationships such as Web-based order entry systems or auctions. This is not to say that EDI systems cannot be used to interact with dozens of suppliers and customers. Instead, each additional EDI customer-supplier link requires a significant effort to integrate the systems, processes, and data definitions between the two partners, resulting in multiple one-to-one relationships with all of the EDI trading partners. In contrast, once an organization integrates its systems with an electronic marketplace, it can engage in multiple trading relationships with minimal incremental effort (Bakos, 1997).

Figure 3. Information and Communication Technologies for Supply Chain Management (after McLaren et al., 2002)



Similarly, the capability of the systems to support unique or customized supply chain processes between the trading partners coincides with the type of relationship for which the system is designed. Since electronic marketplaces are designed for many-to-many supplier-to-customer relationships, they require a high degree of standardization of business processes. In contrast, since systems using EDI or IEAI involve linkages between one customer and one supplier at a time, they can support much more customized and unique business processes.

The other key variable that distinguishes SCM IS is the degree of integration achieved or required between the partners. Tight integration implies a close alignment of the trading processes, systems, and data definitions between the partners and communication that allows information to flow efficiently between the organizations. In contrast, loosely integrated trading partners have significant differences in business processes and data definitions that require substantial human intervention to pass information between the two organizations. Even though EDI achieves tight data integration, it often fails to facilitate the harmonization of business processes and systems amongst the trading partners. By comparison, IEAI usually results in closer alignment of business processes and systems as partners are forced to agree upon a process or use the process models embedded in the enterprise systems. Similarly, when joining an electronic marketplace, companies must align their processes and data definitions with the standards enforced by the marketplace.

Expected Benefits and Costs of SCM IS

Based on a review of previous studies, the following section presents a framework for understanding the net benefits that can be expected from various types of SCM IS. While the expected benefits have been published widely, there has been little focus on the costs of choosing a specific type of SCM IS. However, as can be seen in the failure of many SCM IS to live up to expectations, failure to account for intangible costs, such as the opportunity cost of inflexible IS, can be very risky.

Typical Benefits

Supply chain collaboration initiatives focus on reducing uncertainty in the supply chain, which can lessen the bullwhip effect and lead to lower inventory costs and faster time-to-market (H. L. Lee et al., 1997b). Collaborative partnerships also lead to increased economies of scale and risk sharing (Kumar & van Dissel, 1996). While quantifying these benefits is challenging, several surveys and studies have concluded that the expected benefits of supply chain coordination and collaboration fall into the categories of cost reduction and increased responsiveness (Chopra & Meindl, 2001; Fogarty, 2001; Industry Directions Inc. & Syncra Systems Inc., 2000; Mentzer et al., 2000; Supply-Chain Council Inc., 2002).

Cost reduction benefits include reduced inventory levels, process costs, and product costs that result from the coordination of actual customer demand with supplier production plans. Effective supply chain coordination can eliminate excess inventory, reduce lead times, increase sales, and improve customer service (Anderson & Lee, 1999).

In addition, collaboration has resulted in faster product-to-market cycle times, improved service levels (based on stock outs, lead times, and quality), and a better understanding of end-customer needs throughout the entire chain through market intelligence and demand visibility (Mentzer et al., 2000). However, the level of benefits achievable through collaboration is influenced by a number of factors that have not been well investigated, such as how well the systems support the efficiency and flexibility requirements of the supply chain (Reddy, 2001a) or the level of trust between the trading partners (Karahannas & Jones, 1999). Furthermore, while several studies attest to the transaction cost savings of interorganizational systems (Mukhopadhyay et al., 1995; Seidmann & Sundararajan, 1998), they often ignore hidden costs such as maintenance or errors or the opportunity costs of not being able to trade with other partners due to an inflexible SCM IS.

Typical Costs

The total cost of ownership (TCO) implies the total life-cycle costs of the chosen processes and systems, including cost of systems acquisition, usage, maintenance, dealing with errors and inefficiencies, and integration with partners over the lifetime of the system (Degraeve & Roodhooft, 1999).

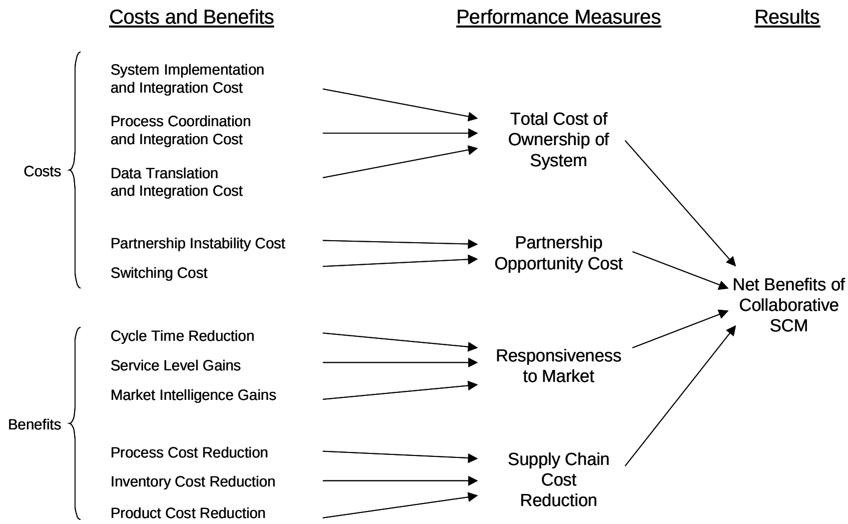
The partnership opportunity cost is the benefits that are foregone from being constrained to trading with specific partners using the SCM IS. The partnership opportunity cost includes the costs of switching partners and costs of partnership instability, both of which are related to the transaction costs involved in searching, contracting, and establishing linkages with trading partners. For example, inflexible systems based on Electronic Data Interchange (EDI) have high costs for switching to other partners, which results in reduced supply chain agility. This is because the inflexibility of the EDI system often precludes the organization from entering into relationships with other partners that could have been of a higher value to the organization (Poirier & Bauer, 2001). In addition, highly flexible systems that do not promote long-term relationships (such as many auction-based systems) will result in instable relationships. This instability results in the partners foregoing the benefits of long-term collaboration, resulting in further partnership opportunity costs, even though the switching costs in auctions are low (Anderson & Lee, 1999). Therefore, a high partnership opportunity cost can result from either high switching costs or high partnership instability, or both.

It is important to note that in supply chain collaboration, low switching costs are desirable. At first, this may seem contrary to Porter's (1985) assertion that high switching costs are desirable for preventing customers from trading with other partners. However, as we have discussed, low costs of switching partners enables organizations to more easily support the relationships that are the most beneficial to the organization and thus lower the opportunity cost associated with a partnership. Indeed, several studies have suggested that partnerships that are maintained through coercion, threats, or high switching costs fail to provide the equity of benefits to both parties that are required for sustainable collaboration (Iacovou et al., 1995; Kumar & van Dissel, 1996).

Thus, *Figure 4* shows how supply chain collaboration benefits fall into two broad categories: enhanced responsiveness to market demands and reduced supply chain costs (Mentzer et al., 2000). The costs involved in SCM IS fall into two broad categories: the total cost of ownership of the IS (Degraeve & Roodhooft, 1999) and the partnership opportunity cost — the cost associated with being tied into a specific partner (Poirier & Bauer, 2001).

In the following subsections, we further describe and analyze the types of SCM IS available for supporting supply chain management and coordination. To

Figure 4. Costs and Benefits of SCM IS (McLaren et al., 2002, used with permission)



highlight the capabilities of more sophisticated computer-based SCM IS, we begin with a brief description of the traditional less-automated approaches. Following a brief description of each type of SCM IS, we outline the expected costs and benefits of each.

Phone/Fax/E-Mail Systems

Traditionally, many supply chain activities have involved the usage of manual and semi-automated phone, fax, and e-mail systems in addition to face-to-face and paper-based transactions. For many functions such as establishing relationships and initial contract negotiations, these methods are indispensable and unlikely to be replaced completely by more automated systems. However, many supply chain processes can be made much more efficient by employing information technology to improve information sharing, reduce errors and rework, and free resources to work on more value-added tasks (O'Leary, 2000).

Phone, fax, and e-mail systems all support highly flexible and customized trading relationships, though they lack standards in their usage. They are very suited for communicating unstructured information but do not support communicating structured information into the recipients' systems electronically. As a result, they do not support a very tight degree of interorganizational integration. While e-mail systems can transmit structured information such as electronic purchase orders directly into a recipient's system, we classify that type of system as EDI. In our classification, we assume that phone, fax, and e-mail messages contain unstructured text or images.

The net benefits accrued from information sharing using phone, fax, and e-mail systems are limited mainly by the fact that the information communicated is difficult to integrate into the receiver's systems without manual processing and data translation.

Offline Auctions/Trade Exchanges

Offline auctions involve one supplier and many customers (in a forward auction) or one customer and many suppliers (in a reverse auction). As the auction process usually focuses on price as the prime decision variable, they have had the widest acceptance in commodity markets. Offline trade exchanges help coordinate similar markets, yet are designed to support many-to-many relationships. Both offline auctions and trade exchanges support only a limited degree of interorganizational integration, as the systems and data are not electronically integrated, and the business processes amongst the trading partners are often disparate and uncoordinated.

Offline auctions and exchanges may yield benefits to a supply chain in increased market efficiency and reduced searching costs, which result in a moderate product and process cost reduction. However, as the information exchanged is typically not integrated with any systems, there is minimal benefit in terms of increased responsiveness of the supply chain or reduction of inventory. As a result, many former offline auctions and exchanges have migrated to online electronic marketplaces (such as the General Electric Trading Exchange) to increase the benefits of integration and coordination amongst their members.

Electronic Data Interchange (EDI)

The traditional method for businesses to exchange operational information electronically has been through sending messages from one computer to another — a process known loosely as Electronic Data Interchange (EDI). Numerous studies have shown that EDI can reduce transaction-processing costs to near negligible levels (Mukhopadhyay et al., 1995; O'Leary, 2000). However, the total cost of ownership of EDI systems is substantial due to the systems and data integration efforts required. Furthermore, this integration effort usually requires a large amount of "hard-coded" data translations, which results in a system that is less flexible in adapting to changing partners, processes, and data structures (Konsynski, 1996).

Two opposing standards that define the format for EDI messages have gained wide usage, although other companies such as Wal-Mart use proprietary formats (Macht, 1995). The ANSI ASC X.12 standard is widely used in North America and the United Nations-backed EDIFACT standard is more common elsewhere in the world. While EDI provides definitions for common message formats to be exchanged, its rigid data model and inflexible formatting requirements force trading partners to expend considerable effort in formatting the data to be exchanged and agreeing upon a common data model to be used (Mukhopadhyay et al., 1995). Furthermore, the systems are proprietary, complex, and costly and sometimes require smaller partners to be coerced into implementing them (Archer & Gebauer, 2000; H. G. Lee et al., 1999). The result is that EDI relationships usually cannot be implemented easily, quickly, or inexpensively (Moore, 2001). This is because the EDI standards focus more on defining the rigid message structure to be used and less on defining which data fields are required for a transaction and how the information should be interpreted.

Thus, two trading partners wishing to exchange EDI messages need to first agree upon how to structure and interpret the messages and then must configure their systems to translate their legacy data into this common format. If one of the partners then wanted to exchange EDI messages with a third organization, it would need to start the negotiations all over again with that party in order to adopt a common data model (Moore, 2001). As each party would like to use their own data model and minimize the data translation required, the likely outcome is that organizations would need to translate their data separately for each of their trading partners rather than being able to use one common model. The result is high system and data integration costs. On the positive side, since EDI participants must adhere to common standards, the costs of coordinating their processes are lower than most of the alternatives.

Since most organizations are incapable or unwilling to support EDI transactions with numerous diverse partners, EDI trading networks often follow a hub-and-spoke architecture centred on the dominant customer rather than a web-like network. For example, in the retail sector, Wal-Mart has had sufficient influence with its suppliers to mandate the use of proprietary formatted EDI messages in order to do business with Wal-Mart (Macht, 1995). This arrangement creates a barrier to entry for Wal-Mart competitors, as it makes it less likely that the suppliers will adopt different EDI message formats for smaller customers who have a different data structure than Wal-Mart.

While Wal-Mart currently enjoys the purchasing power to mandate such usage of EDI with its suppliers, it is an adversarial strategy that few customers can afford to maintain. Even for Wal-Mart, once more flexible collaboration alternatives become available to its suppliers, they will be forced to reconsider this strategy. In general, the inflexibility of the EDI hub-and-spoke model has disadvantages to both suppliers and customers, as it makes it costly to share information electronically with alternative trading partners.

Inter-Enterprise Application Integration/Extended ERP

Inter-enterprise application integration (IEAI), sometimes known as "Web services," is also a standards-based messaging approach to integrating systems similar to EDI. However, it usually implies the use of XML-formatted messages and integrated enterprise-wide systems rather than rigid EDI formats and disparate legacy systems. IEAI in a supply chain usually involves one-to-one integration between enterprise applications, including legacy systems, ERP, SCM, or advanced planning and scheduling (APS) systems.

Extended ERP (EERP or ERP II) involves the sharing of information electronically between two ERP systems and can be done using industry-standard or proprietary EDI or XML formats. However, it increasingly uses open XML formats rather than traditional EDI messaging. Since EERP is a type of IEAI, we will not distinguish between the two further.

In contrast to the "send-and-receive" approach of EDI, IEAI often uses a "publish-and-subscribe" approach to achieve the same benefits of electronic information exchange in a more flexible manner using the Internet and Extensible Markup Language (XML) message formats. However, the distinctions between EDI, IEAI, and XML Web services approaches are often blurred, as there is frequently a mix of proprietary and standards-based approaches used.

The usage of data tagged in XML formats enables different organizations to view the same shared data in the format they prefer. As long as two organizations agree upon the meaning of a piece of data, they may use different XML "schemas" to present the information differently to their users. For example, if one organization calls a quantity of product "a skid of soda" and the other calls it a "pallet of pop," they must standardize the unit of measure in the database but then could use different XML schemas to translate that unit of measure back to the preferred terminology in their own systems (Marron, 2001).

The prime benefit in using XML for EDI or IEAI is that it allows the data fields in business documents to be identified using XML tags, rather than requiring rigid file layouts, as in traditional EDI. Though the location of the data in the document is no longer important, a shared understanding of the meaning and usage of those fields is still critical. While XML is more flexible in dealing with structured data transactions, like traditional EDI, it still requires adoptions of common standards for exchanging business documents. However, unlike EDI, XML provides a facility to interpret and validate documents against an electronic version of these standards (often called schema). Hence, it is easier for trading partners to develop and maintain their own flexible standards, whereas changes to the EDI standards require all parties to update their software or manually agree upon which versions they will support, which is much more cumbersome.

Compared to traditional EDI, IEAI or EDI using XML provides a more efficient means of sharing structured data between organizations (Glushko, Tenenbaum, & Meltzer, 1999). However, one can imagine that there is little benefit to each organization using their own XML schema. Instead, some industry groups and software vendors have banded together to try to establish their own XML vocabularies and schema repositories. Examples of these include FinXML and FpML for finance; ebXML, cXML, OTP, and PDML for general e-commerce; SAEJ2008 for the automotive industry; RNIF for the electronics industry; and many more. Again, one can see that "standards" often are not standard, and "interoperability" usually has very narrow applicability. Even in single industries, there are competing XML vocabularies, often spearheaded by competing companies or solution providers seeking industry dominance (McLaren, 2001).

Web-Based Order Entry Systems

Web-based order entry systems, sometimes referred to as business-to-consumer (B2C) or business-to-business (B2B) Web sites or customer portals, enable customers to interact directly with a supplier's sales order system. As opposed to eProcurement applications, Web-based order entry systems reside on the supplier's computers. Since the customer manually enters the information, the degree of systems and data integration between the customer and supplier is loose, even though the supplier's systems may be internally integrated. Furthermore, since the customer must conform to the supplier's business processes, the degree of process integration or coordination between the two parties is also loose. Note that if transactions are predominately communicated electronically rather than entered manually, we classify those systems as EDI or IEAI systems, which are discussed in the preceding sections.

With Web-based order entry systems, the information exchanged between the customer and supplier is consistent with the supplier's system, resulting in a lower error rate and minimal rework of the information, as compared to voice- or paper-based transactions. However, while the supplier does not need to translate the information (as it is already entered into their system), the customer is required to do a mental translation of their processes and information into the process and format required by the supplier's order entry system. Thus, the supplier experiences efficiency gains from the integration, while the customer experiences fewer such benefits, especially after having to learn how to interact with several different supplier Web sites.

These systems are also designed primarily for transactional information processing, rather than tactical or strategic supply chain collaboration. For example, most Web-based order entry systems do not make tactical information such as actual product availability or lead times available, which would provide more of a benefit to their customers. In a system that benefits the supplier much more than the customer, the efficiency gains of integration are self-limiting because the customers have low switching costs and will tend to seek out relationships that are more desirable. As a result, organizations participating in supply chains primarily dependent on Web-based order entry systems will experience only a moderate level of cycle time reduction, service level gains, and market intelligence gains due to the partial integration of information (McLaren et al., 2002).

Note that if strategic planning information were made available to the customers on the Web site, such as “available-to-promise” data, then the collaboration gains would increase. However, again, the lack of integration with the customer’s systems and processes would limit the benefits realized. If the information were integrated with the customer systems, then the system would be better termed a hub or portal, as described in the following section.

Electronic Procurement Hub/Portal

Systems that support the electronic procurement of goods or services typically take the form of customer or supplier portals, hubs, marketplaces, or trading exchanges. There are usually architectural differences behind each of these terms; however, the terms are often used interchangeably and their distinction is not terribly important to this discussion of ICTs. In general, electronic procurement systems, hubs, or portals focus on facilitating electronic catalogue-based orders from select supplier partners, whereas electronic marketplaces (which are discussed in the next section) are geared towards competitive sourcing and auction mechanisms, though these distinctions are often blurred.

Procurement hubs or portals are generally Web-enabled SCM IS that allow an organization to electronically integrate its systems and processes to some degree with those of its trading partners. An “electronic procurement portal” usually includes electronic supplier catalogues and functionality to submit purchase orders electronically to the supplier from within the portal application. Typically, the customer performs most of the effort of integrating the supplier catalogues into the electronic procurement system. A “supplier portal or hub” usually refers to a Web site belonging to an organization that allows its suppliers to integrate their systems and processes with that of the organization (Stevens, 2001). In this chapter, we will refer to each of these types of systems as electronic procurement portals. In contrast, a "customer portal" is another term for a Web-based order entry system, which was discussed in the preceding section.

An example of a supplier portal is one created by automotive manufacturer Volkswagen Group (VW). The VWGroupSupply.com portal provides access to VW's procurement and planning systems for their suppliers. Upon implementing this portal for their suppliers, Volkswagen Group has reported a 95% reduction in business process times, improved planning accuracy, and reduced inventory levels (Waheed, 2001).

Electronic procurement systems increase the efficiency of trading partners by integrating the data, processes, and systems utilized in a supply chain. They can lead to lower product prices through spending consolidation and process efficiencies (Archer & Yuan, 2000); however, the biggest savings come from ensuring purchasing compliance by reducing off-contract buying and forcing purchases to be made against established contracts (Hope-Ross, Lett, Luebbers, & Reilly, 2000).

The benefits of electronic procurement solutions come at a cost of the integration and translation efforts required to facilitate the electronic transactions amongst the partners (Archer & Gebauer, 2000). Though they can result in lower transaction costs, the cost of maintaining different electronic catalogues for different customers and from integrating these into another organization's systems can be high (Ginsburg, Gebauer, & Segev, 1999).

However, as integrating and aggregating information between applications in a supply chain using portal technology can be done incrementally and often quite cheaply, the payback period is usually much shorter than large-scale supply chain integration projects involving enterprise application integration (Reddy, 2001b). Furthermore, since large supply chain integration projects may span several companies and functional areas, it is difficult to measure return on investment (ROI) and hard to justify in times of economic uncertainty. Thus, portals for supply chain collaboration allow quick wins by facilitating information sharing and increasing the usability of disparate systems.

Electronic Marketplaces/Trading Exchanges

Electronic marketplaces or trading exchanges "are online business-to-business (B2B) community groups that link participants to a global network of buyers and sellers" (Stevens, 2001, p. 30). They can include public marketplaces hosted by a third party or private trading exchanges hosted by a supply chain participant. They usually include capabilities for product sourcing and ordering such as electronic catalogues, online auctions, and sometimes approvals routing and contract management (Archer & Gebauer, 2000). Public trading exchanges can be hosted by individual distributors (such as W.W. Grainger for indirect materials), consortiums (such as Covisint for automobile manufacturers), or third-party market makers (such as CommerceOne, Chemdex, or eSteel; Dagenais & Gautschi, 2002; Kaplan & Sawhney, 2000). However, because of factors such as trust and market liquidity (attracting enough participants and transactions), private trading exchanges have typically been more successful than public trading exchanges (Dagenais & Gautschi).

Like EDI, electronic marketplaces have proven useful for integrating supply chains for some organizations but have not been as widely accepted as had been predicted. There are several obstacles to participating fruitfully in an electronic marketplace, including supplier resistance, buyer resistance, connectivity, and return on investment (ROI) issues (Dagenais & Gautschi, 2002; Stevens, 2001). Initially, suppliers have been reluctant to join electronic marketplaces as the highly competitive auction process usually involved has to date been focused primarily on achieving unsustainably low prices. Price-focused auctions commoditize the goods or services sold and drive suppliers who are unwilling to further reduce their margins to seek alternative trading relationships in which they can compete on non-price terms, such as quality and service levels (White, 2000).

Therefore, in order to gain more acceptance with suppliers, electronic marketplaces will need to facilitate negotiations on other terms, such as quality, service level, and payment terms, and support longer-term contracts. Otherwise, many suppliers will continue to focus more on building less flexible one-to-one connectivity with their strategic partners (Stevens, 2001).

Likewise, buyers are hesitant to join marketplaces that do not support the robust types of negotiations that are required for long-term successful relationships. They also have legitimate concerns about having their supply chain transactions and planning forecasts so easily visible to their competitors in the marketplace. Furthermore, buyers in industry-specific marketplaces, such as Covisint, have found it difficult to come to agreement with their business rivals upon the required infrastructure, processes, and standards required to support the transactions.

Ultimately, despite the low infrastructure costs of the Internet and the emergence of promising technologies such as XML, the present state of B2B connectivity has not progressed far beyond the rigid standards of EDI. While the Internet has reduced the cost of bandwidth, most trading situations still require significant investment to translate legacy data into some format agreed upon by the marketplace participants (Ginsburg et al., 1999). Since there is presently no agreed-upon standard that is sufficiently flexible to accommodate all trading partners, organizations must expend a significant amount of resources to set up those linkages to the marketplace and other partners they need to interact with. In many cases, it has been impossible to meet the payback period requirements of less than a year, which has become the minimum criteria for many IS projects (Stevens, 2001).

The result has been that few electronic marketplaces have achieved the trading volumes that were originally budgeted for and many have been dissolved within years of their launch (Dagenais & Gautschi, 2002; Stevens, 2001). Nonetheless, as technology and standards evolve, electronic marketplaces hold considerable promise for reducing transaction costs and enabling tighter collaboration throughout the supply chain.

Shared Collaborative SCM IS

The preceding IOS are all similar in their approach of facilitating collaboration through system integration. In contrast, the use of shared or jointly owned collaborative systems takes a different approach that eliminates much of the integration and translation efforts but instead focuses upon reaching mutual agreement upon a shared process and system. These systems could include jointly owned dedicated supply chain management systems or could include the conventional planning, forecasting, and product design modules from ERP or APS systems, such as SAP or i2, which have been made accessible for partner access. More recently, software vendors such as Logility and Syncra Systems have created add-on or stand-alone packages that provide even greater collaboration capabilities, such as data transformation, planning calendar synchronization, and flexible views of the information for supporting the different needs of the partners (Peterson, 1999). It is anticipated that these advanced collaboration capabilities will be incorporated into the next generation of ERP and APS software.

Shared collaborative SCM IS go beyond mere sharing of operational data such as production schedules and available-to-promise capabilities. They also facilitate exchange and coordination of tactical information such as supply and demand forecasts and may even assist strategic planning through trade network design and optimization (Kumar, 2001).

Through their support of joint planning initiatives such as CPFR, shared collaborative SCM IS can greatly reduce the bullwhip effect and yield more accurate demand forecasts (Barratt & Oliveira, 2001). Both the supplier and customer jointly agree upon supply and demand forecasts and plans and can coordinate their promotion and distribution strategies. The result is more predictable demand, which lessens the amount of inventory required in the supply chain and reduces the amount of exception processing and expediting required, leading to cycle time reduction and service level gains (Anderson & Lee, 1999; Mentzer et al., 2000). Furthermore, the joint collaboration allows a high level of market intelligence to be shared throughout the supply chain, as customers, distributors, and suppliers can all share information about customer needs (Anderson & Lee).

The process coordination costs involved with shared collaborative SCM IS are high, as each partner must adapt their own unique business processes to the jointly coordinated process. Similarly, both parties must agree upon a mutual data format and must translate and integrate the shared data with their own systems, resulting in a high data translation and integration cost. However, since the shared system acts like a single hub, the system integration costs are not expected to be as high as in many point-to-point EDI or IEAI solutions. The system interface costs are a function of the number of partners that need a different system interface, and therefore the centralized or shared systems are expected to have lower system integration costs than the point-to-point solutions (Ginsburg, 1999).

Furthermore, since two or more partners invest in the shared system, the cost of switching partners is high. Although this limits flexibility, since the shared collaborative SCM IS usually have large benefits for both the customers and the suppliers in a trading relationship (Anderson & Lee, 1999), the relationships are often more sustainable and the costs of partnership instability are lower.

Using the Cost-Benefit Model to Select an SCM IS

This section explains how researchers and practitioners can use the cost-benefit model along with other decision criteria to select an SCM IS that best fits their strategies and requirements.

As was shown in *Figure 4*, the net benefits of an SCM IS are derived from the total costs of ownership, the opportunity costs due to inflexibility, the enhanced market responsiveness, and the amount of supply chain cost reduction. In general, the lowest cost alternatives can be expected to yield the least amount of benefit from collaboration (McLaren et al., 2002). Similarly, the SCM IS offering the high potential benefits of collaboration have higher costs of ownership and opportunity costs. The exception is EDI systems, which tend to have high opportunity costs due to their inflexibility and a high total cost of ownership due to high ongoing system and data integration costs (Moore, 2001). *Figure 5* shows a generalized relationship between overall costs and benefits for different types of SCM IS.

Since the costs generally increase with the benefits, then the decision of which type of SCM IS to deploy often comes down to the question of how tightly does the firm need to be integrated with its partners in order to achieve the desired degree of supply chain collaboration. In other words, the type of IOS that should be deployed depends primarily on the level of interdependence of the partners (Kumar & van Dissel, 1996).

There are three levels of interdependence of trading partners (Robey & Sales, 1994; Thompson, 1967). The first level of interdependence is “pooled dependency,” whereby firms are independent but must share a common resource. An SCM IS to support pooled dependency might include an electronic marketplace that gives participants access to a database of qualified suppliers and their product catalogues. The second level is “sequential dependency,” where the output of a process becomes the input of a process in another firm. An SCM IS example might be an EDI-based system for sending and receiving purchase orders between two established partners. The third level of interdependency is “reciprocal dependency,” wherein inputs and outputs flow recursively between the organizations. An SCM IS example is a collaborative portal used by Wal-Mart to support joint planning, forecasting, and replenishment activities with their key suppliers (Dagenais & Gautschi, 2002).

A higher degree of interdependence can reduce the bullwhip effect and lead to better-optimized supply chains (H. L. Lee et al., 1997a). However, as the level of interdependence of organizations increases, so does the potential for conflict, the impact of failed relationships, and the resulting risk. While higher interdependency can lead to many collaborative benefits, the information systems and coordinating mechanisms become more important and must rely less on rules and standards and more on joint planning, mutual adjustment, and trust (Kumar & van Dissel, 1996).

Thus, organizations need to consider a number of factors when selecting an appropriate SCM IS. The number of trading partners involved and degree of interorganizational integration or interdependence with each dictate whether an SCM IS should be chosen that is optimized to support one-to-one, one-to-many, or many-to-many trading partner relationships. Similarly, how standardized or customized the trading processes are will also dictate the type of SCM IS, as shown in *Figure 3*. However, since this is only a rough guideline, firms should analyze the expected costs and benefits of each option using the model shown in *Figure 4*. It is critical that the cost-benefit analyses include not just the cost of implementing the SCM IS, but also the ongoing costs of systems, process, and data integration as well as the opportunity costs of trading partner inflexibility.

Conclusions

Supply chain management information systems (SCM IS) have become important tools for supporting collaborative commerce among the customers and suppliers of a supply chain. However, the rate of innovation in information and communication technologies for supporting supply chain collaboration has made the selection of appropriate SCM IS a difficult and risk-prone decision.

The benefits of using SCM IS to support supply chain collaboration have been clearly demonstrated by several large and powerful companies, such as Dell Computers, Wal-Mart, and Cisco Systems (Dagenais & Gautschi, 2002; Koch, 2002; Magretta, 1998). However, other firms such as Nike (Smith, 2001) have had more problematic experiences selecting and implementing SCM IS. For smaller firms with less influence over their trading partners' processes and information systems, the difficulties can be considerable, although there are still numerous success stories (Dagenais & Gautschi).

In this chapter, we have attempted to make the selection of SCM IS a less risky decision for firms by providing a framework for analyzing the costs and benefits that can be expected for various types of SCM IS. The benefits of using SCM IS fall into two categories: reduced supply chain costs and enhanced responsiveness to market demands. Supply chain cost reduction benefits include reduced inventory levels, process costs, and product costs that result from the coordination of actual customer demand with supplier production plans. Enhanced responsiveness includes faster product-to-market cycle times, improved service levels (based on stock outs, lead times, and quality), and a better understanding of end-customer needs throughout the entire chain through market intelligence and demand visibility.

The costs of SCM IS include the total cost of ownership (TCO) of the IS and the partnership opportunity cost. TCO includes the total life-cycle costs of the chosen processes and systems, including cost of IS acquisition, usage, maintenance, dealing with errors and inefficiencies, and integration with partners over the lifetime of the system. The partnership opportunity cost is the benefits that are foregone from being constrained to trading with specific partners using the SCM IS. The partnership opportunity costs includes the costs of switching partners and costs of partnership instability, both of which are related to the transaction costs involved in searching, contracting, and establishing linkages with trading partners. Thus, high partnership opportunity costs could result from an inflexible system (such as EDI) that involves high costs of switching partners or a very flexible system (such as a public marketplace) that precludes long-term, stable trading relationships.

Using the cost-benefit model developed, together with an understanding of the processes and level of interorganizational integration required, firms can make better informed decisions about the type of SCM IS that will best fit their needs. While other factors such as the level of trust between the partners and the technical capabilities of the SCM IS are also critically important, the model presented helps ensure decision makers do not overlook important costs or benefits in their analyses. Using this model, researchers and practitioners can develop more realistic cost-benefit analyses of SCM IS and develop appropriate strategies to minimize their risks while maximizing the benefits of supply chain collaboration.

Endnotes

1 Portions of this chapter originally appeared in *Internet Research: Electronic Networking Applications and Policy*, vol. 12, no. 4, 2002, and are used with permission of the publisher.

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