Research paper

Business process improvement through electronic data interchange (EDI) systems: an empirical study

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Keywords

Electronic data interchange, BPR, Customer orientation

Abstract

Explores the effect of EDI systems on business process improvement (BPI) and the moderating effect of information intensity of the industry on the relationship between EDI systems and BPI. The data for the study were gathered through a survey of *Fortune* 1,000 US firms at branch levels. The results of study support the hypotheses that EDI systems spanning between a firm and its suppliers have a direct and significant relationship with BPI factors. Information intensity of the industry was not found to moderate the relationship between EDI systems and BPI; rather, it was found to have a direct and significant impact on BPI factors.

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Introduction

In the present dynamic environment, organizations are required to reduce product development cycle time, improve customer service, and enhance product and service quality. To meet such challenges, many businesses are developing closer relationships with their suppliers with the application of interorganizational information systems (Kumar and van Dissel, 1996). Electronic data interchange (EDI), electronic fund transfer (EFT) and automatic transaction machines (ATMs) are common examples of such systems. EDI systems are used to share data between suppliers and customers in standardized formats over value-added computer networks.

Prior research has explored EDI implementations from both operational and strategic perspectives (Benjamin *et al.*, 1990; Malone *et al.*, 1987). Operationally, EDI is considered to reduce product development cycle time and costs, by improving the accuracy, timeliness, and speed of standard document exchange (Carter *et al.*, 1987; Mukhopadhyay *et al.*, 1995). Strategically, EDI systems have been considered as major enablers to fundamentally change the way many organizations conduct their businesses (Cash and Konsynsky, 1985; Malone *et al.*, 1987). In many firms, EDI systems have become major information technology (IT) platforms on which they are initiating and implementing business improvement initiatives (Venkatraman and Zaheer, 1990).

In spite of a general understanding of the useful roles of EDI systems on business process improvement (BPI), empirical studies examining the relationship between EDI systems and BPI are scarce in the literature. Though there have been some studies which have looked at the relationship between EDI systems and BPI, the majority of these studies are case-based descriptions. This paper aims to fill this gap and empirically examine the relationship between EDI systems and BPI. The moderating effect of information intensity of the industry on the relationship between EDI systems and BPI is also examined. The data for the study were obtained from *Fortune* 1,000 firms at the branch levels. A total of 1,100 survey questionnaires were randomly mailed to branch managers from a database of 1,600 branches obtained from a marketing vendor.

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A total of 124 responses were received, out of which 105 responses were usable.

In the next section, a brief explanation of EDI systems and BPI is given. The third section describes the hypotheses linking EDI systems and BPI. The data analysis and results are discussed in the fourth section and the limitations and conclusions are presented in part five.

Defining EDI systems and business process improvement (BPI)

Electronic data interchange (EDI) collaborations usually involve long-term information technology (IT) arrangement between two or more firms (usually a firm and its major suppliers) for sharing of data and documents (Kumar and van Dissel, 1996). The trading partners in EDI systems make use of computer and telecommunications technology to exchange standard business documents and data along an extended value chain between the supplier and the firm (Johnson and Vitale, 1993).

In this paper, our definition of EDI systems will be limited to the computer and communication linkages between a firm and its major suppliers. Because of empirical concerns to maximize the variance of the independent factors, in this study focus on electronic linkages (i.e. between suppliers to suppliers, professionals working together on the basis of social networks rather than legal contacts, and intraorganizational electronic linkages between a firm and its major customers) that are between two or more firms, except a firm and its major suppliers.

The use of EDI systems requires integration across the firm's legal boundaries, encompassing a network of suppliers and the firm. However, the establishment of these linkages rests on the presumption of the compatible IT infrastructure between suppliers and the firm (Emmelhainz, 1993). Traditionally, a number of suppliers were forced to implement EDI to conduct their business with their major suppliers. However, with recent advances in information technologies and TCP/IP computing standards, a number of firms have begun to take advantage of Internet-based EDI products, extranets, and virtual public network (VPN)-technology (Kalakotla and Whinston, 1996).

In contrast to traditional EDI systems, the use of these latest technologies has been found to enhance firms' strategic flexibility and co-ordination capabilities (Bradley and Nolan, 1998). Traditional EDI links between suppliers and customers comprise the exchange of messages containing standard business objects – invoices, purchase orders, or electronic funds. The impact of these EDI systems on improving the value chain is limited, as these systems are unable to adapt to rapidly changing markets.

The differences between traditional EDI and Internet-based EDI lie in the types of networks and the complexity of the protocols used by these systems. Traditional EDI applications are conducted using value added networks that use proprietary protocols, while the Internet-based EDI-products and extranets use TCP/IP communication protocol.

Business process improvement (BPI) refers to making businesses efficient, effective, and flexible to meet customer expectations in products and services (Harrington, 1991, pp. 15-25). It involves finding the root causes of problems so that an organization can provide quality goods and services to customers (McNealy, 1993).

Because BPI is a process-oriented approach of improvement, it is important for the firm to break its rigid functional structure and work through cross-functional orientations that may involve making long-term alliances with suppliers and customers.

A number of quality experts, including Crosby (1979), Deming (1982), and Juran (1992) have broadly defined two dimensions of BPI:

(1) process improvement initiatives; and
(2) customer focus.

Process improvement initiatives

The main aim of the process improvement initiative is to eliminate waste (i.e. scrap, rework, returned goods, cost of warranties, settling customer claims, and other redundant activities (Juran, 1989). In general, process improvement initiatives are grouped under three categories: defect prevention, improvement actions, and cost of quality deficiencies (Crosby, 1979; Deming, 1986; Juran, 1992).

Defect prevention refers to avoiding making mistakes in the first place. The purpose is to create products with zero defects. This

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emphasis, from error detection to prevention, makes it essential that the firm pays attention to the overall effectiveness of its processes rather than increasing the efficiency of a function (Cameron *et al.*, 1993).

Improvement actions refer to continual upgrading of the quality standards in business processes. That means organizations over time not only prevent errors from occurring in the first place but also try to reach new standards of quality by upgrading their capabilities in process improvement (Cameron *et al.*, 1993).

Cost of quality deficiency refers to reducing excess cost in manufacturing a product or offering a service, by reducing waste. An organization, which makes its primary goal to streamline and improve its business processes, begins reducing the number of steps and handoffs in carrying and completing its tasks.

Customer focus

Customer focus is the corporate mantra these days. It refers to meeting customers' expectations in products and services. Because of the dynamic expectation of customers, organizations need to continually survey and identify their customers' expectations. For example, by keeping track of customer complaints and causes of their dissatisfaction, an organization can proactively plan to avoid making several of the errors in the future (Schmidt and Finnigan, 1992).

Wheelwright and Clark (1992, p. 16) argue that clarity of the objective, focus on time to market, and high quality prototypes often provide competitive advantages to firms, as these firms can meet customers' demands in new products and services quickly. A shared understanding among organizational members about the dynamics of product innovation, active anticipation of customers' needs and resolution of inter-functional problems are important criteria for introducing high quality products to customers (Rosenthal, 1992).

Framework

Because an EDI system spans across a company's boundaries, it demands continual support and encouragement from suppliers and buyers. The encouragement can come in various ways: the promise for extending a long-term relationship with involved parties, the sharing of costs between participants in time and resources, and exchanging of information for quick adjustment of inventories upstream and downstream (Emmelhainz, 1993). When a firm makes it mandatory that its suppliers adopt EDI systems, it usually provides EDI software free to its suppliers to encourage adoption (Riggins and Mukhopadhyay, 1994).

Since the 1980s, businesses have realized that cost reduction is only a single facet of competitiveness. The demand is to offer quality goods at lower price and bring new products and services to the market earlier than competitors. To compete in such a dynamic environment, businesses have realized that manufacturers and buyers must develop closer relationships to work in co-ordination. Adoption of an EDI system between the trading partners is one way through which suppliers and buyers set such long-term relationships for sharing their co-ordinated efforts (Clemons *et al.*, 1993). Adoption of EDI systems, according to Bakos and Treacy (1986), can reduce transaction costs between the buyer and the seller, and therefore can provide the advantage to the participants (Bakos, 1991). Riggins and Mukhopadhyay (1994) argue that as firms begin to work in close co-ordination through EDI systems, they also begin to change their internal processes to take the maximum advantage of EDI systems in data accuracy, timeliness of data, and document handling. Through co-ordination of tasks and sharing of process knowledge, an EDI system can result in the improvement of the quality of the products and services, and an overall reduction in the cost of performing the transaction. The basic research model is shown in Figure 1.

Research hypotheses

In the following section, we analyze the effect of EDI systems on each of the BPI factors and set out the research hypotheses.

EDI systems and process improvement initiatives

Benjamin *et al.* (1990) suggest that an EDI system enables legally independent firms to co-ordinate interdependent tasks. For

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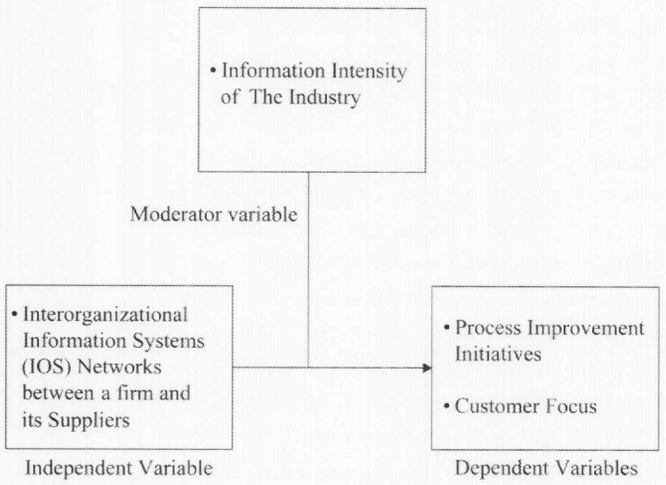
Figure 1 Research model – the relationship between EDI networks and BPI with moderating effect of information intensity of the industry



example, by using EDI systems, a firm can easily exchange its quality information about its new product designs to its primary supplier of components, which helps in reducing the costs of product manufacturing and the product development cycle time. By reducing transaction costs, EDI systems can enhance buyer and seller relationships, reduce inventory problems, and induce business process improvement (Mukhopadhyay *et al.*, 1995). In addition, EDI systems enable the capturing and processing of accurate and timely information, which facilitates co-ordination across two or more business units and organizations (Rockart and Short, 1991).

Because data are not required to be entered at the receiving end and a large volume of data can be transmitted instantaneously through EDI systems, it can substantially increase the accuracy of the data and reduce the amount of clerical effort in conducting the transactions. For example, major auto manufacturers now use EDI systems with their suppliers to exchange information on production schedules and ship notices (Hammer and Champy, 1993). When a part clerk at a Honda dealership places an order on a computer terminal, the system immediately transmits information to ten regional warehouses to speed up delivery of parts, prevent errors, and slash cost (Harrington, 1991). Similarly, EDI systems can result in building long-term relationships with a few suppliers, accounting for substantial cuts in clerical overhead in managing fewer relationships (Juran, 1992).

H1: A higher level of EDI system use is related to a higher level of process improvement initiatives.

EDI systems and customer focus

Malone *et al.* (1987) argue that EDI systems may result in reduction of co-ordination costs, which would induce a firm to make more use of markets than hierarchies. That means by using electronic networks, a firm can reduce costs of communication, co-ordination and logistics by exchanging a larger volume of information in less time. Electronic networks can enhance the quality of products and services, as they can be used to monitor a supplier's production and quality processes.

From the resource-based view (RVB) of the firm, organizations are likely to enter into EDI collaboration for two reasons: first, to pool the market risks, and second, to exploit complementary resources from each other to bring new products and services quickly in the markets. By linking with suppliers and customers, a firm can better manage its inventory and meet customers' demands in products and services by creating customer intimacy (Carter *et al.*, 1987; Johnson and Vitale, 1993). The extended collaborations enable a firm not only to speed up customer service, but also manufacture and bring new products and services quickly to the market place. By capitalizing on the capabilities of its suppliers and customers, a firm becomes flexible and responsive to customer demands in products and services (Byrne and William, 1991).

H2: A higher level of EDI system use is related to a higher level of customer focus.

Moderating effect of information intensity of the industry

Information intensity of the industry refers to the amount of information needed to develop, produce, and use a product or service (Capon and Galzer, 1987; Glazer, 1991). In an information intensive environment, firms are often pressed to make quick decisions toward restructuring of business processes. Also, higher information intensive products require continual process improvement because of the short product development cycle time (Davenport, 1993).

Information intensive firms often work with complex and dynamic environments. The use of Internet-based EDI systems not only

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provide easy and quick access to complementary information and knowledge from external participants, but also enable them to quickly adapt to changing and dynamic environments. Many Internet-EDI systems enable firms to offer information content in products and services, besides facilitating the process of product/service customization and information analysis for understanding the changing market trends (Glazer, 1991). By using EDI systems, a firm can augment traditional products and services features with information contents, thus providing higher value to the customers (Porter and Miller, 1985).

H3: The relationship between EDI systems and process improvement initiatives will be stronger where the information intensity of the industry is high and weaker where the information intensity of the industry is low.

H4: The relationship between EDI systems and customer focus will be stronger where the information intensity of the industry is high and weaker where the information intensity of the industry is low.

Research methodology

The data for the study were collected through a survey. A database vendor was requested to provide a randomized mailing list of 1,600 branches of *Fortune* 1,000 companies. From this list, 1,100 questionnaires were randomly mailed to different branch managers.

A total of 124 responses were received, of which only 105 responses were found usable. Therefore, for data analysis, only 105 firms were used. The effective response rate was about 10 per cent. However, given the relatively complex nature of the questions, spanning from business processes to information systems areas, this kind of low response rate is not considered to be unusual. Moreover, in many *Fortune* 1,000 companies, the supply and purchase operations are handled centrally, rather than at the branch level, and in some other cases the branch managers are not directly involved with the ways these operations are conducted. Nevertheless, given the exploratory nature of the study, a response rate of 10 per cent was considered satisfactory.

Development of the measurement scales

Based on Churchill's (1979) guidelines for developing reliable and valid measures, multiple items measuring EDI systems, BPI, and information intensity of the industry were developed. The measurement scales were revised based on the inputs and feedback obtained from six academicians and middle-level managers and pilot tested with 20 firms at branch level, 12 from manufacturing and eight from service firms, all in the St Louis area, to ensure the face validity, i.e. appropriateness and comprehensiveness of items included. The pilot test included structured interviews with the branch managers. The structured interviews were carefully noted and any problem related to items was carefully reviewed by the pilot group. Based on their comments, the items were either deleted or reworded.

For measuring EDI systems use, we based our scales on the studies of Powell and Dent-Micallef (1997), Mukhopadhyay *et al.* (1995), Riggins and Mukhopadhyay (1994), Rockart and Short (1991) and Kraut *et al.* (1998). For measuring process improvement initiatives and customer focus, the studies of Saraph *et al.* (1989), Flynn *et al.* (1994) and Powell (1995) were used. The information intensity of the industry was measured on the basis of Porter and Miller's (1985) and Glazer's (1991) studies.

All the variables were measured with five-point interval scales. In all of the above items, except customer focus and information intensity of the industry, respondents were asked to mark an answer, varying from 1 to 5, where 1 is "not at all", 3 is "moderate extent" and 5 is "very large extent", to represent the current status of their division/firm. Customer focus was measured in relative terms in comparison to the industry. Respondents were asked to mark an answer on each of the items, varying from 1 to 5, to represent the relative standing of their firms on the industry: 1 is "worst in the industry", 3 is "equal to the industry" and 5 is "best in the industry". Each of the five items on information intensity of the industry was measured varying from 1 to 5: 1 is "strongly disagree" with high information intensity of the division, 3 is "neither agree nor disagree" and 5 is "strongly agree" with high information intensity of the division/firm (see the Appendix).

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Data analysis

A preliminary analysis of data showed that none of the 105 questionnaires were received from two branches of the same firm. In other words, all of the 105 questionnaires were received from different *Fortune* 1,000 company branches.

Table I shows the branch profiles of the respondent firms. A majority of branches were from defense/space, financial, chemical, construction, and consumer services.

To test for the response bias, a chi-square test between sample revenue and population revenue was conducted. The chi-square test was not found to be significant, thus indicating the sample as being representative of the population.

Table II shows respondent profiles in the sample. A majority of respondents in our sample were IS managers, manufacturing managers, and marketing managers. The rest were finance managers and production managers. Seeing the nature of the items in the questionnaires, it could be that branch managers passed the questionnaires to those people who were probably involved in IT and management areas.

Reliability and validity analysis

To test reliability analysis, we followed Nunnally's (1978) guidelines in developing items and pre-testing them for clarity and appropriateness. To assess the reliability of the measures, the Cronbach Alpha co-efficient was estimated (Cronbach, 1951). For each set of items measuring a specific scale, Cronbach Alpha was computed. A value greater than 0.70 was considered appropriate for the analysis (Kerlinger, 1973).

In the first step, for the items measuring each variable, the reliability analysis was performed. In the next step, all of the items, measuring independent and dependent scales, such as EDI systems, process improvement, and customer focus were thrown together to analyze the construct validity. Table III shows the loading and the Cronbach Alpha of the revised set of items.

Content validity is not computed numerically. It is judged by the researchers. It represents the adequacy with which a specific domain of contents has been sampled (Nunnally, 1978). Determination of content validity, according to Nunnally (1978), is determined based on two criteria: first, to determine that an instrument contains a representative collection of items, and second, a satisfactory method to test the instrument is used.

To meet the first criterion, the variables used for this study were based on prior research studies. Through an extensive review of the past literature, an elaborate list of the items for each of the variables was generated. The list of items, in consultation with two academicians and six practitioners, was refined and redundancies and inconsistencies in the items were eliminated. To meet the second criterion, the questionnaire was pilot tested with 20 firms to ensure that the instrument contains a representative collection of items (the original list of items is shown in the Appendix).

To test the convergent and divergent validity of the items, a principal component analysis was conducted (Kerlinger, 1973). All items used to measure independent and dependent variables, i.e. EDI, process improvement initiatives, and customer focus were subjected to the analysis. The rotated solution revealed four significant components with an eigenvalue of 1 or greater. The factors are presented in Table III. The information intensity of the industry indicated only one factor, as shown in Table IV. These results provide evidence of convergent and divergent discriminant validity with all of the measures demonstrating high consistency with their respective dimensions and low scores on alternate dimensions.

Table I Industry profile

Industry	Frequency	Per cent	Cumulative per cent
Defense/space	24	22.86	22.86
Financial	15	14.28	37.14
Chemical	13	12.38	49.52
Construction	12	11.43	60.95
Consumer services	10	9.52	70.47
Health	8	7.62	78.09
Others	23	21.91	100
Total	105	100	

Table II Respondent profile

Title	Frequency	Per cent
IS managers, VP-IS, and systems managers	46	43.80
Manufacturing managers, VP-manufacturing	32	30.47
Marketing managers, VP-marketing	18	17.15
All others	9	8.57
Total	105	100

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Table III Factor analysis: EDI systems and BPI

Items	Factor 1 reliability coefficient = 0.89	Factor 2 reliability coefficient = 0.87	Factor 3 reliability coefficient = 0.84 (customer responsiveness)	Factor 4 reliability coefficient = 0.87 (product development capability)
The firm and its major suppliers are linked through information systems for replenishment of inventory	0.87			
The firm and its major suppliers can share product design or service specification related information	0.84			
Work processes are checked continuously to prevent defects in products/services		0.82		
Work processes in the business are designed to be defect-free to eliminate unexpected human errors		0.74		
Work processes are evaluated continually for improvement		0.89		
Process improvement standards are raised periodically		0.82		
New work processes that are introduced are easier to work with than earlier ones		0.71		
Work processes support multiple tasks simultaneously		0.74		
Analysis of customer requirements in products/services				0.68
Continuous improvement of existing products/services				0.88
Development of innovative products/services				0.87
Quality of products/services				0.77
Analysis of customer feedback in products and services			0.65	
Responsiveness to customer orders and delivery			0.86	
Responsiveness to customer queries			0.87	

Note: Less than 0.30 loading is not reported

Table IV Factor analysis: information intensity of the industry

Items	Factor 1 reliability coefficient = 0.78
Firms need a lot of information for customization	0.71
Products/services are complex to use	0.82
Product/service R&D requirements are high	0.83
Selling of product/service requires specialized knowledge	0.83
Customer needs a lot of information to order products and services	0.83

Note: Less than 0.30 loading is not reported

Testing the hypotheses

Before testing the hypotheses, we conducted correlation analysis between EDI, process improvement initiatives, customer responsiveness, product development capability, and information intensity of the industry as shown in Table V. Because of a high level of multicollinearity between EDI systems use and information intensity of the industry (with a variance inflationary factor >5), it became evident that examining the moderating effect of information intensity of the industry on the relationship between EDI systems use and BPI would not provide any useful information. Therefore, we examined the separate independent effect of EDI systems, and information intensity of the industry on process improvement initiatives, customer responsiveness, and product development capability, as shown in Table VI.

For testing the main hypotheses, three separate simple regression analyses were conducted. Revenue (in logarithmic form) was used as a control variable, although its effect on process improvement initiatives, customer responsiveness, and product development capability was not found to be significantly related. Therefore, revenue was not considered for further analysis. Next, the independent effect of EDI systems was analyzed. The independent effect of EDI was found to be significantly related to process

Table V Correlation matrix

	EDI	Information intensity	Process improvement	Customer responsiveness	Product development capability
EDI 2.97 (1.25)	1.00	0.47**	0.40**	0.46**	0.21*
Information intensity					
3.31 (0.86)		1.00	0.19*	0.45**	0.16
Process improvement					
3.28 (0.78)			1.00	0.43**	0.42**
Customer responsiveness					
3.90 (0.70)				1.00	0.63**
Product development capability					
3.70 (0.69)					1.00

Notes: ** correlation is significant at 0.01 level (2-tailed); * correlation is significant at 0.05 level (2-tailed); mean and standard deviations ( ) are shown in the first column corresponding to each of the factors

Table VI Regression analyses: independent effect of EDI and information intensity of the industry on process improvement initiatives, customer responsiveness, and product development capability

Independent variables	Model 1 (a)	Model 1 (b)
Effect on process improvement initiatives		
EDI systems	0.405** (0.053)	
Information intensity		0.195** (0.083)
Adjusted R-square	0.15	0.03
Effect on customer responsiveness		
EDI systems	0.460** (0.26)	
Information intensity		0.450** (0.068)
Adjusted R-square	0.20	0.20
Effect on product development capability		
EDI systems	0.219** (0.051)	
Information intensity		0.160* (0.075)
Adjusted R-square	0.03	0.01

Notes: **significant at 0.01 level (2-tailed); *significant at 0.05 level (2-tailed); standardized beta and corresponding standard error is shown

improvement initiatives (R^2 = 15 per cent, p = <0.01), customer responsiveness (R^2 = 20 per cent, p = <0.01), and product development capability (R^2 = 3 per cent, p = <0.01). Similarly, the independent effect of information intensity of the industry was analyzed. The independent effect of information intensity of the industry was also found to be significantly related to process improvement initiatives (R^2 = 3 per cent, p = <0.01), customer responsiveness (R^2 = 20 per cent, p = <0.01), and product development capability (R^2 = 1 per cent, p = <0.05) (see Table VI).

Discussion of the results

Hypotheses 1 and 2, i.e. the main effect of EDI systems on process improvement initiatives, customer responsiveness, and product development capability were supported by the survey results, while hypotheses 3 and 4 were not. We also found that information intensity of the industry directly and significantly affects process improvement initiatives, customer responsiveness, and product development capability.

These results provide support for the contention that EDI systems facilitate improvement initiatives and the creation of a clear customer focus. The use of applications eliminates not only many redundant processes, but also provides opportunities for co-ordinating and integrating many disparate interorganizational processes. Schmidt and Finnigan (1992) have elaborated on the advantages of EDI by arguing that improvements in interorganizational

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processes directly lead to new products and services in the marketplace and increase customer responsiveness in products and services.

By exploiting external links between its suppliers and customers, a firm can exploit complementary knowledge that offers the advantages of streamlining its internal processes and meeting customer demands in products and services. That is one of the reasons that many firms which develop long-term ties with their suppliers gain advantages in process improvement and customer intimacy (Mukhopadhyay *et al.*, 1995). For example, many Japanese firms, such as Toyota, Honda, and Cannon, which have established long-term alliances with suppliers and dealers, are consistently being found to be more quality oriented and customer focused than the other firms (Davenport, 1993).

The other insight from the results of the study is that EDI systems may have far less influence on a firm's capability in developing innovative products than it has on customer responsiveness. This could be because development of products and services requires a strong R&D base, higher-order learning, and experimentation with new ideas and prototypes. These capabilities are developed over time, and considered to be path dependent (Powell, 1995). Therefore, EDI systems do not seem to produce as much effect on product development capability as on the customer responsiveness. On the other hand, customer responsiveness, a derivative of sales and marketing, requires first-order-learning and process flexibility, which can be influenced through EDI systems, as a number of recent studies have shown the positive effect on EDI systems on first-order-learning (Hammond, 1993). EDI systems enable sales and marketing people to handle customer orders, billing, and invoicing much more easily and allows them to respond to customer queries efficiently.

We believe that the results of this study may only reveal a partial picture of the current use of the computing networks between firms and their suppliers. As argued earlier, a number of firms have begun to shift from traditional EDI to Internet-based EDI products, extranets, and VPN-technology to link with their suppliers. These technologies are much more flexible and enable firms to enhance their strategic flexibility and co-ordination capabilities (Bradley and Nolan, 1998). Certainly, the use of TCP/IP-networks may enhance the product development capability of the firm, as they are flexible and can be used to enhance informal communication and knowledge sharing between different collaborative participants to focus on the critical issues. This interaction process also enables firms to synthesise knowledge from different sources across a common frame of reference (Upton and McAfee, 1998). Because of the inflexibility and limited roles of the traditional EDI on the value chain, a growing number of firms are adopting the use of Internet-based EDIs, extranets, and VPN-technology, which offer flexibility and quick co-ordination capabilities between different trading partners.

The information intensity of the industry significantly influences process improvement initiatives, customer responsiveness, and product development capability. That means, firms working in high technology and knowledge intensive industries will be more motivated to quickly improve their processes, as they need to bring new products and services quickly to the marketplace, because of the relatively rapid product development time. In higher information intensive environments, existing services and products continually need upgrading and it becomes critical for the companies that they put a premium on improving their work processes to quickly develop and deliver quality products in the marketplace to capture and lock-in the customers.

The effect of information intensity explains only about 1 per cent of variance in product development capability as compared to 20 per cent in customer responsiveness. That means, a high level of information intensity of the industry does not automatically make a firm capable of bringing new products and services to the market. After all, product development capability is path dependent, which requires time, effort and higher order learning. Therefore, information intensity of the industry does not seem to drastically affect a firm's product development capability. In product development, the historical constraints and learning capabilities are far more important. However, information intensity of the industry can affect customer responsiveness much more, because customer responsiveness requires first order learning, which can often be supported by IT

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infrastructure. By automating a number of information intensive processes, a firm can respond to customers' queries, demands, and complaints efficiently and effectively. By automating information intensive processes, a firm not only offers benefits by reducing errors, but also provides 24-hour service to the customers.

Again, we believe that as firms begin to make use of standard TCP/IP protocols in linking between major customers, suppliers, and manufacturers, they will, over time take advantage of information intensity. Electronic commerce (e-commerce) offers the latest evidence of this trend. Although the e-based economy is still evolving, it shows how companies can capitalize on the speed of computer networks in bringing new products quickly to the marketplace. Moreover, we also believe that higher information intensity in an industry may in fact be conducive to the use of computer networks for sharing knowledge across the firms.

Limitations of the study

There are a number of limitations of this study of which the reader should be aware. The sample consists of branches of *Fortune* 1,000 firms. *Fortune* 1,000 companies are well established and large in size. The results of the study are, therefore, limited for the purpose of generalization. However, we believe the results can still offer important guidelines for replicating the study over a larger sample of smaller firms.

Many small companies may not have the internal infrastructure needed to adopt the EDI system. While there are several EDI products that allow firms to adopt some form of EDI even with minimal computer technology, other types of EDI may not be feasible to many smaller firms. For example, an interorganizational CAD/CAM document exchange system may not be feasible for many small suppliers. In our study, we did not differentiate between the different levels of EDI systems, therefore the study does not predict what level of EDI use actually influences process improvement initiatives and customer focus. This could be one of the reasons that some of the results of the study are diluted. For example, EDI and information intensity of the industry do not have any significant effect on product development capability. A sample, from firms that are using Internet-EDI products, extranets, or VPN-technology to link their major suppliers, might provide a better understanding of the effect of the EDI systems on BPI.

The sample size is another limitation of this study. The responses pertaining to 105 divisions did not provide sufficient basis to revise our theoretical model. The results from a larger and more heterogeneous sample might provide a better basis to revise the theoretical framework.

Conclusion

In the present dynamic environment, EDI systems may be critical for firms to share complementary knowledge between firms and their suppliers. The pressure is not toward reducing the cost of production alone, but to increase the quality and the timeliness of new product development and services in a fast and dynamic environment. EDI systems can offer advantages of high quality products/services, low-cost, and timeliness of information in responding to customer inquiries.

By exploiting complementary knowledge from external sources, EDI systems enable a firm to quickly streamline its internal work processes to meet customers' shifting demands quickly. Also, EDI systems enable firms to quickly acquire and process information across their boundaries, thus allowing the advantage of co-ordination to bring new products and services quickly to the marketplace.

EDI systems are traditionally being used extensively in the automotive and retail areas, but in the current dynamic environment, a growing number of firms are beginning to use Internet based-EDI products, extranets, and VPN-technology, which offer the advantages of flexibility to co-ordinate between several trading partners simultaneously.

The recent trend in organization research indicates that suppliers, customers, and competitors are the sources of significant information for knowledge creation. Flexible computer-to-computer links between firms can facilitate the process of quick feedback, knowledge sharing, and knowledge refining between firms, suppliers, and customers.

Internet-based EDI products, extranets, and VPN-technology can offer the advantages of knowledge sharing, speed, and strategic flexibility to trading partners. This may be especially true, because while EDI implementation is usually controlled by a dominant trading firm, the Internet-based EDI, extranet, and VPN implementation offer equal opportunities to all trading partners, irrespective of their size, to collaborate and reciprocate.

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Appendix: questionnaire items

Please answer the following questions based on the business-branch in which you are mostly involved.

EDI systems

(1) The firm and its main suppliers are linked through information systems (e.g. EDI, EFT, or extranet systems):
1 not at all
2 to some extent
3 to a moderate extent
4 to a large extent
5 to a very large extent

(2)* Through information systems, senior management can distribute product or service related (e.g. specification, design, quality, etc.) information to the firm's suppliers:
1 not at all
2 to some extent
3 to a moderate extent
4 to a large extent
5 to a very large extent

(3) Through information systems, both suppliers and firm can share product or service (e.g. specification, design, quality, etc.) related information:
1 not at all
2 to some extent
3 to a moderate extent
4 to a large extent
5 to a very large extent

Process improvement initiatives

(1) Work processes are checked continuously to prevent defects in products/services:
1 not at all
2 to some extent
3 to a moderate extent
4 to a large extent
5 to a very large extent

(2)* Work processes are controlled to ensure their correctness:
1 not at all
2 to some extent
3 to a moderate extent
4 to a large extent
5 to a very large extent

(3)* Emphasis is on eliminating the root causes of work processes in the business:
1 not at all
2 to some extent
3 to a moderate extent

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4 to a large extent
5 to a very large extent

(4) Work processes in the business are designed to be defect-free to eliminate unexpected human errors:
1 not at all
2 to some extent
3 to a moderate extent
4 to a large extent
5 to a very large extent

(5) Work processes are evaluated continually for improvement:
1 not at all
2 to some extent
3 to a moderate extent
4 to a large extent
5 to a very large extent

(6) Process improvement standards are raised periodically:
1 not at all
2 to some extent
3 to a moderate extent
4 to a large extent
5 to a very large extent

(7)* Redesign in work processes are implemented after through testing:
1 not at all
2 to some extent
3 to a moderate extent
4 to a large extent
5 to a very large extent

(8) New work processes that are introduced are easier to work with than earlier ones:
1 not at all
2 to some extent
3 to a moderate extent
4 to a large extent
5 to a very large extent

(9) Work processes support multiple tasks simultaneously:
1 not at all
2 to some extent
3 to a moderate extent
4 to a large extent
5 to a very large extent

Customer focus

(1) Analysis of customer requirements in products/services:
1 worst in the industry
2 worse than the industry
3 equal to the industry
4 better than the industry
5 best in the industry

(2) Continuous improvement of existing products/services:
1 worst in the industry
2 worse than the industry
3 equal to the industry
4 better than the industry
5 best in the industry

(3) Development of innovative products/services:
1 worst in the industry
2 worse than the industry
3 equal to the industry
4 better than the industry
5 best in the industry

(4) Analysis of customers' complaints in products/services:
1 worst in the industry
2 worse than the industry
3 equal to the industry
4 better than the industry
5 best in the industry

(5) Quality of products/services:
1 worst in the industry
2 worse than the industry
3 equal to the industry
4 better than the industry
5 best in the industry

(6) Responsiveness to customer orders and delivery:
1 worst in the industry
2 worse than the industry
3 equal to the industry
4 better than the industry
5 best in the industry

(7) Responsiveness to customer queries:
1 worst in the industry
2 worse than the industry
3 equal to the industry
4 better than the industry
5 best in the industry

Information intensity of the industry

(1) Firms need a lot of information for customization:
1 not at all
2 to some extent
3 to a moderate extent
4 to a large extent
5 to a very large extent

(2) Products/services are complex to use:
1 not at all
2 to some extent
3 to a moderate extent
4 to a large extent
5 to a very large extent

(3) Product/service R&D requirements are high:
1 not at all

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2 to some extent
3 to a moderate extent
4 to a large extent
5 to a very large extent

(4) Selling of product/service requires specialized knowledge:
1 not at all
2 to some extent
3 to a moderate extent
4 to a large extent
5 to a very large extent

(5) Customers need a lot of information to order products and services:
1 not at all
2 to some extent
3 to a moderate extent
4 to a large extent
5 to a very large extent

* Shows the item did not survive the test of reliability and therefore was deleted from further analysis.