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Deepak Khazanchi

University of Nebraska at Omaha, khazanchi@unomaha.edu

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The Nature and Structure of Impediments to EDI Adoption and Integration: A Survey of Small- and Medium-Sized Enterprises

DEEPAK KHAZANCHI

College of Business, Northern Kentucky University, Highland Heights, KY 41099

Electronic data interchange (EDI) is a key enabling component of business-to-business electronic commerce. As firms adopt and integrate advanced information technologies such as EDI, it is important to understand the nature of challenges faced by them. This becomes especially important given the fact that nearly 99.7% of all businesses in the US can be classified as small- to medium-sized enterprises (SMEs). As costs and risks associated with implementing new information technologies decrease, these firms will surely need to focus their attention on managing impediments associated with new technology implementation and learn from the failures or successes of their peers. Consequently, this article reports the findings of a study conducted to understand the characteristics, seriousness, and structure of impediments faced by SMEs. A survey of 353 EDI-capable firms was used to assess the impediments faced by SMEs adopting and integrating EDI. Analysis of data revealed that SMEs face many serious challenges when implementing EDI and cite high startup costs, difficulty of learning a new technology and methodology, and high cost of integration and expansion of EDI use as among the three most significant impediments. Further analysis also produced an eight-factor latent structure that best describes the nature of EDI impediments. These results have implications for both SMEs and researchers.

Electronic data interchange; E-commerce; Small- to medium-sized enterprises (SMEs)

INTRODUCTION

Interorganizational systems such as electronic data interchange (EDI) have the potential of changing the way organizations do business. EDI has become a critical business tool for many large companies (Compaq, 1997; JC Penney, 1997). It is also a critical element of all future business-to-business electronic commerce. In 1995, "of the 5 million to 6 million companies in the U.S. with revenue greater than \$1 million, only about 80,000—or less than 1%—were using EDI" (Mohan, 1995). Corporate America's EDI-related expenditures are expected to grow to \$6.4 billion by the turn of the century.¹ Furthermore, it is predicted that almost 90% of all businesses will use some form of electronic data transfer in their operations by the end of the century. However, small companies that are at the receiving end of the EDI mandate have failed to obtain the benefits promised by this technology. They are faced with the adoption of a technology that results in enormous challenges for the organization and in some instances has become a drain on the firm's resources.

Small- to medium-sized enterprises (SMEs) employing less than 500 employees constitute 99.7% of all

businesses in the US and consequently dominate the typical supply chain of most large companies (EDI World Institute, 1995; National Federation of Independent Business, 1997; Small Business Administration, 1995). Thus, any new information technology (IT) initiative (or imperative) from federal or state level procurement agencies and larger corporate organizations has critical ramifications for small- to medium-sized firms. Although many research studies have investigated the business impact of EDI on large corporate organizations in various industrial sectors (e.g., Arunachalam, 1995; Banerjee & Golhar, 1993; Bergeron & Raymond, 1992; Hansen & Hill, 1989; Hendon, Nath, & Basu, 1995; Massetti, 1991; Pfeiffer, 1992; Vlosky, Smith, & Wilson, 1994), very few have specifically focused on analyzing the impact of EDI on SMEs (e.g., EDI World Institute, 1995; Iacovou et al., 1995; Raymond & Bergeron, 1996).

Therefore, the goal of this article is to describe the findings of a research project undertaken to address the specific issues relating to identifying and evaluating the nature and seriousness of impediments associated with EDI adoption and integration in SMEs.

RESEARCH RATIONALE AND QUESTIONS

The impact of EDI on small businesses can be answered with one word—devastating. After being on EDI for over two years, spending hundreds of hours quoting the

Correspondence and requests for reprints should be addressed to Deepak Khazanchi. Tel: (606) 572-6408; E-mail: khazanchi@nku.edu

¹This estimate includes four revenue components: transaction (VAN, direct, Internet), software (purchase, upgrade, integrate), consulting (internal, external), and hardware (fixed cost) (EDI Group, 1997).

federal government over two million dollars of products that are on GSA Contracts and not receiving a dime's worth of business, I can only say forget it. . . . All of my business with the government is being done outside of EDI, and I will continue to do business in this manner until it is no longer feasible or profitable. I would rather close this business than go through another two years of frustration working through EDI. . . . I have talked with various people (and government organizations) . . . but they really don't want to hear about the "down" side of EDI. [Extracted from a letter sent to the author by a SME owner in December 1997. Parenthetical comments added for clarification].

The above reaction is not uncommon from SMEs, especially as many large (hub) corporations, the federal and state governments are mandating the use of EDI in their procurement activities. Small firms have little choice but to install EDI without too much forethought or planning. Past research has focused on the potential merits of EDI adoption and integration, factors that influence the ability of small and large firms to obtain operational and strategic benefits from EDI, and the financial and technological readiness of firms (Bergerson & Raymond, 1992; Iacovou et al., 1995; Raymond & Bergeron, 1996).

Although some researchers have identified key challenges or perceived barriers to EDI adoption (cf. Arunachalam, 1995; Pfieffer, 1992), very few researchers have attempted to characterize the nature and structure of EDI impediments, especially in the context of small firms.

Impediments to EDI Adoption and Integration

EDI impediments are challenges, hurdles, barriers, or obstacles that are faced by organizations attempting EDI implementation and integration. These impediments may have an impact on the different phases of the EDI implementation process: preimplementation (adoption) phase, implementation (or installation) phase, and postimplementation (or integration phase). In a multiple-case study of the factors that motivate and inhibit implementation of new computer-based information systems, Cragg and King (1993) report that limited resources and lack of education were the most crucial constraints. In a similar vein, Iacovou et al. (1995) found that the availability of financial and technological resources affects a small firm's ability to adopt or integrate EDI. For the purpose of this research, the different impediments to EDI adoption and integration culled from extant literature and two case studies conducted by the author (Khazanchi, 1995) were conceptually organized into the following four distinct categories.

- **Technical challenges** such as maintaining multiple EDI systems, complexity of the technology, lack/absence of standards, etc.
- **Organizational challenges** such as gaining management commitment, overcoming the small size of SME, business process reengineering, etc.

- **Resource challenges** such as high startup costs, availability of financial and technological resources, etc.
- **Education/training-related challenges** such as understanding potential benefits of EDI, the challenge of learning a new technology, obtaining general information about EDI, etc.

Research Questions

The previous discussion provides the impetus for this research study. There are two related questions addressed in this article. What is the nature and seriousness of impediments to EDI adoption and integration faced by SMEs? What (if any) is the structure of the "impediment" construct? In other words, are there underlying factors associated with EDI impediments?

RESEARCH METHODOLOGY

A survey research design was adopted to elicit the data needed to address the research questions posed in the previous section. The survey questions were designed on the basis of past literature and two case studies on the impact of EDI adoption in small businesses. Pilot test and initial validation of the survey items was done by circulating the survey to a panel of three experts in survey design. Many survey items were revised, reformulated, simplified, and reformatted to make them easy to read and understand.

Instrumentation

Respondents were asked to rate each EDI impediment item on a 3-point Likert-type scale with verbal labels ranging from "not serious at all" (coded as a 1), "somewhat serious" (coded as a 2), and "extremely serious challenge" (coded as a 3). A "not an impediment" (coded as a 0) response was also provided. In addition, an ordinal, open-ended question was included to elicit the three major EDI impediments faced by responding firms. Demographic data for the responding SMEs were also collected.

Data Collection

The survey was mailed to 353 EDI-capable SMEs in the Commonwealth of Kentucky.² Nearly half of these companies were identified from the EDI World 1998

²The research questions addressed in this article were part of a larger EDI study partially funded by the Kentucky Cabinet for Economic Development. In consequence, the sampling frame for the study was limited to the Commonwealth of Kentucky. Because the basic characteristics of Kentucky SMEs are representative of firms from across the nation, the results reported in this article are potentially generalizable to the larger SME population.

directory and the remaining were located by approaching EDI hub companies and government organizations in the area. Anonymity was promised in return for completed surveys. Various measures to reduce nonresponse rates were also undertaken. In order to boost response rates, nearly 418 follow-up phone calls were made. Approximately 338 companies were called once, 79 called twice, and one was called three times. The first follow-up was done after 2 weeks of the initial survey mailings. After the first follow-up a total of 59 completed survey responses were received giving a response rate of 16.7%. Based on the first follow-up phone call, businesses that had expressly indicated an interest in participating were identified and called the second time around. These efforts culminated in an effective response rate of 24.3%, that is, 86 useful responses.

RESULTS AND DISCUSSION

Description of Survey Sample

Industrial Sector and Range of Products. All 86 responding firms provided information about their industrial sector. The two largest categories are manufacturing (57%) and wholesale trade (27%) making up nearly 84% of the sample. The remaining include a large number of retail (7%) and services sector (2%) firms. The responding firms offer a range of products and services. In the manufacturing sector, participating firms make a diverse range of products including everything from industrial parts and supplies to candy and cheesecakes. In the wholesale trade sector, firms deal in products ranging from industrial parts and supplies to food and pharmaceuticals. The remaining firms are involved in retail trade such as office furniture and power tools, services such as health and lab analysis, and other business activities such as hauling freight, warehousing, logistics management, and computer systems value-added reselling (VAR).

Respondent's Position. Survey respondents representing the sampled organizations were also asked to identify their position and functional area. An equal number (43) of individuals belonged to the nontechnical managerial or administrative ranks as those from the information systems branch. This result is interesting in that it is a positive change from the reported respondent profiles in previous studies.³ It is also in line with the notion that EDI is an organizational problem rather than a purely technical one. The result also demonstrates that this concept is gradually shaping how small firms plan to use new information technologies in the long term.

Organizational Size. Nearly 49% of the responding firms have less than 100 full-time employees with 36% having less than 50 employees. Organizations with more than 100 employees but less than 500 made up 36% of the sample. A large number (nearly 70%) of responding firms had gross sales over \$1 million in 1997 with more than half (47%) generating over \$10 million in sales. The remaining firms were evenly split between \$10,000 and \$1 million in gross sales. Nearly a dozen firms (14%) did not reveal their sales numbers by marking "don't know."

EDI Experience.⁴ *New EDI users*, organizations with EDI experience of less than or equal to 12 months, made up nearly 10% of the number of respondents. *Experienced EDI users*, organizations with more than 1 year and less than 5 years of experience made up 56% of the sample. *Long-term EDI users*, organizations with more than 5 years of experience, made up nearly 34% of the sample.

Characteristics of EDI Operation in Surveyed Organizations

Means of Communication. There are three generic approaches to implementing EDI links (Jillovec, 1993). The first approach involves the use of a direct EDI link between vendor and customer using a modem and telephone line. Trading partners establish communications using a dial-up link to the hub's network. While a majority of these hubs do not charge for their network service, trading partners do have to pay all phone charges.

The second approach involves using indirect EDI links through value-added networks (VAN) or "third-party electronic clearing houses" between trading partners. These independent EDI networking vendors provide all the necessary software and communications services and essentially perform the function of an electronic post office for numerous business partners. Trading partners place their business documents in "electronic envelopes" identifying the sender and receiver. The document is mailed to the VAN after setting up a dial-up link via phone lines. The VAN will either forward the document to the hub organization's computer automatically or place it in the receiver's mailbox for pickup at a later time. Major costs associated with this EDI transmission option will include expenses relating to VAN setup, telephone lines, and monthly transaction fees.

With the development of better Internet browsers and compatible EDI software that incorporates adequate security measures including encryption, the robust and cheaper Internet is fast becoming a medium of choice

³For example, both Pfeiffer (1992) and Bergeron and Raymond (1992) found that EDI was largely the responsibility of an organization's technical (IS) manager.

⁴The classification of EDI experience used here is based on Pfeiffer (1992).

Table 1. Means of EDI Communication (N = 86)

Type of Connection	Frequency	Percent of Responses	Percent of Cases
Third-party EDI network/value-added network (VAN)	75	72.1%	87.2%
Direct link or point-to-point network	23	22.1%	26.7%
Internet	5	4.8%	5.8%
Other (Fax to EDI)	1	1.0%	1.2%
Total	104	100%	120.9%

for transmitting electronic documents and messages. The third approach is essentially similar to the direct communications link except that Internet access charges are substantially lower than the other options.

In accordance with the above conceptualization, survey respondents were asked to identify *all* methods of communications used for transmitting EDI documents (see Table 1). A large majority (87.2%) use a VAN and/or a proprietary third-party network as their primary means of communications with trading partners. Furthermore, a substantial number of firms use a direct or point-to-point link (26.7%) to transmit their transactions. This finding is interesting because most of the sampled firms are experienced with EDI (as evidenced earlier), but are still only at the first stage of EDI integration within the firm.⁵ Also, only a minority of firms (5.8%) currently utilize the Internet for EDI transmissions. Finally, only one firm uses "fax to EDI" as a means for communication.

Interestingly, the results shown in Table 1 also demonstrate that a number of firms use more than one means of EDI communication. Nearly 21% (18) of the sampled firms utilize more than one means of communication. In all likelihood, most of these firms use a direct or point-to-point link and a VAN/third-party network because of the differing requirements of their primary customers. This occurs because of a lack of seamless standardization within industries at the present time.

EDI Standard. The survey also asked responding firms to identify the EDI standard (format) that they were using. Because many firms use multiple formats, respondents were allowed to check more than one EDI standard. The prevalent EDI standard is the nationally accepted ANSI X.12 format. It is being used by nearly three fourths of the firms in the sample.

Beyond the ANSI X.12 standard, industry standards

such as UCS, VICS, and others are used by nearly 20% of the firms. Not surprisingly, the internationally accepted EDI standard (EDIFACT) is mostly ignored at present with only two firms reporting that they use it. It must be noted that a significant proportion of businesses (13) communicate with their business partners using multiple EDI standards.

EDI Platform. A significant majority of the surveyed organizations (35%) continue to run EDI software on a DOS platform. However, it is important to note that an equivalent number of firms (37%) employ a "Windows or Windows95" platform to run EDI. A significant proportion of sampled firms (13%) use UNIX or WINDOWS-NT operating systems. An equal number of firms use other operating systems such as OS/400, AS400, MAC OS, VMS for their EDI platforms.

Volume of EDI Communication. Sample firms were asked to characterize the volume of EDI documents (messages) exchanged with trading partners. The number of EDI messages exchanged per period can have a potential impact on the perceived success of EDI as an effective business tool. If we define⁶ *low-volume EDI* users as firms with less than 10 transactions per day, then nearly two thirds of the enterprises fit into this category with nearly 21% exchanging less than one transaction per day. A majority of the firms (44%) exchange between 1 and 10 transactions per day. If we define *medium-volume EDI* users as firms with more than 240 (10 per day) but less than 2400 (100 per day) transactions per month, then nearly 27% of the sample fit this category. It is interesting to note that a small but significant minority (8%) of the sample firms can be considered as *high-volume EDI users*, exchanging in excess of 100 transactions per day (2400 per month).

The Nature and Seriousness of EDI Impediments

When companies implement EDI they face various challenges, hurdles, or difficulties. In order to understand the nature of impediments faced by Kentucky

⁵According to Swatman and Swatman (1991) and Swatman, Swatman, and Fowler (1994), in the first stage (level) of EDI integration firms use this technology merely as a high-end fax machine. Generally, in this stage incoming business documents (EDI messages) are electronically received and printed. A staff member is required to key-in outgoing messages. EDI software is run on a stand-alone PC or terminal.

⁶This classification of EDI volume is based on Pfeiffer (1992).

Table 2. Major EDI Impediments Ordered by Frequency of Response

EDI Impediment	Frequency
Availability of managerial time to expand EDI use	27
Ability to seamlessly integrate EDI with existing internal applications	12
Learning new technology and methodology	11
High startup costs	10
High cost of integration and expansion of EDI use	10
Changing business processes	8
End users' and customers' continued reliance on paper-based transactions	8
Low volume or frequency of orders	7
Maintaining one system for EDI-capable and another for non-EDI-capable partners	7
Availability of technological resources	7
Understanding potential benefits of EDI	6
Impersonal nature of EDI	5
Other impediments	N/A

SMEs, surveyed organizations were asked two questions. The first asked respondents to identify the *top three* impediments faced by their organizations. The second question attempted to assess the *seriousness* of these barriers or impediments to EDI adoption, implementation, and integration.

The three most *frequently mentioned impediments* faced by small- to medium-sized organizations in Kentucky are “availability of managerial time to expand EDI use,” “ability to seamlessly integrate EDI with existing internal applications,” and “learning new technology and methodology.” Table 2 lists the other major impediments ordered by the number of firms identifying a given item as an impediment.

However, the three major impediments by ranking are “high startup costs,” “low volume or frequency of orders,” and “maintaining one system for EDI-capable and another for non-EDI-capable partners.” This is based on the list of top three impediments written in by each responding firm. The analysis of this survey question is presented in Table 3. The table was generated

by first assigning a rank score of 1 to each top listed impediment, 2 to the next listed impediment, and 3 to the last listed impediment. Next, these ranks were used to calculate a “mean rank score” for all the impediments.

The apparent difference between the two results (frequency vs. average rank of top three impediments) can be further analyzed by studying the results of the seriousness of each EDI impediment presented in Tables 4 and 5. Respondents from the sampled firms rated the seriousness of each EDI impediment by choosing a “not an impediment for us” (0), “not serious at all” (1), “somewhat serious challenge” (2), and “extremely serious challenge” (3). The higher the mean “seriousness of impediment” scores the more difficult the impediments are to overcome.

Table 4 represents an analysis of frequencies for each impediment item when the responses are treated as ordinal categories. This result has been sorted on the sum of the “extremely serious challenge” and “somewhat serious challenge” responses. Clearly, nearly 29 of 31 listed impediments were considered to be somewhat to ex-

Table 3. Major EDI Impediments by Rank

EDI Impediment	Mean Rank Score
High startup costs	1.13
Low volume or frequency of orders	1.42
Maintaining one system for EDI-capable and another for non-EDI-capable partners	1.42
Availability of technological resources	1.57
Understanding potential benefits of EDI	1.80
End users' and customers' continued reliance on paper-based transactions	1.87
Availability of managerial time to expand EDI use	1.93
Ability to seamlessly integrate EDI with existing internal applications	2.00
Learning new technology and methodology	2.00
Impersonal nature of EDI	2.00
Changing business processes	2.87
High cost of integration and expansion of EDI use	3.00
Other impediments	N/A

Table 4. Seriousness of EDI Impediments (Frequency Statistics)

EDI Impediments	N	Extremely Serious Challenge	Somewhat Serious Challenge	Not Serious at All	Not an Impediment for Us
High startup costs	83	15.7%	54.2%	26.5%	3.6%
Learning new technology and methodology (e.g., trading partner's procedures)	83	16.9%	45.8%	24.1%	13.3%
High cost of integration and expansion of EDI use	83	14.5%	45.8%	28.9%	10.8%
Changing business processes (new way of thinking about & doing business)	83	9.6%	47.0%	26.5%	16.9%
Translating customer/supplier data for direct use in internal applications	84	15.5%	40.5%	25.0%	19.0%
End users' and customers' continued reliance on paper-based transaction	83	13.3%	42.2%	33.7%	10.8%
Ability to seamlessly integrate EDI with existing internal applications	84	26.2%	27.4%	29.8%	16.7%
Availability of managerial time to expand EDI use	82	20.7%	32.9%	30.5%	15.9%
Exposure to ever-changing customer/supplier requirements about EDI system	81	9.9%	40.7%	32.1%	17.3%
Availability of technological resources	83	13.3%	36.1%	37.3%	13.3%
Absence of uniform EDI standards	84	15.5%	33.3%	32.1%	19.0%
Complexity of the technology itself	84	9.5%	39.3%	39.3%	11.9%
Availability of financial resources	83	12.0%	36.1%	41.0%	10.8%
Implementing multiple trading partners	83	12.0%	32.5%	33.7%	21.7%
Understanding potential benefits of EDI	82	17.1%	26.8%	42.7%	13.4%
Overcoming resistance to change	82	7.3%	36.6%	37.8%	18.3%
Dealing with multiple EDI formats	84	11.9%	31.0%	28.6%	28.6%
Considering EDI as a natural extension of preexisting internal operations	83	12.0%	28.9%	44.6%	14.5%
Increased responsibility for employees	82	4.9%	35.4%	41.5%	18.3%
Obtaining general information about EDI	83	9.6%	28.9%	50.6%	10.8%
Managing data and transmission security and auditability (e.g., lack of audit trails)	82	4.9%	30.5%	36.6%	28.0%
Maintaining one system for EDI-capable & another for non-EDI-capable partners	83	9.6%	24.1%	24.1%	33.7%
Determining appropriate internal applications to apply EDI	83	6.0%	27.7%	48.2%	18.1%
Integrating multiple EDI systems and/or VAN connections	83	10.8%	21.7%	36.1%	31.3%
Gaining management/stakeholder commitment	82	3.7%	25.6%	45.1%	25.6%
Impersonal nature of EDI (e.g., lose touch with customers/suppliers)	81	8.6%	19.8%	40.7%	30.9%
Small size of our business	81	6.2%	21.0%	46.9%	25.9%
Addressing legal issues (e.g., electronic orders, signatures, legal agreements)	81	2.5%	23.5%	42.0%	32.1%
Low volume or frequency of orders	83	13.3%	12.0%	47.0%	27.7%
Selecting means for communications with trading partners (e.g., choice of third-party VANs)	84	2.4%	22.6%	52.4%	22.6%
Selecting the hardware to run EDI software	84	3.6%	20.2%	48.8%	27.4%

tremely serious challenges by nearly one quarter of the responding firms. Almost 10 (out of 31) listed impediment are considered somewhat to extremely serious challenges by nearly half of the responding firms. The three major impediments identified as being somewhat to extremely serious challenges include (ordered by frequency) "high startup costs," "learning new technology and methodology," and "high cost of integration and

expansion and use." (More than 60% of the responding firms agreed that these three were their top impediments in terms of degree of seriousness.) It is also interesting to note that a number of responding firms also cited various impediments as being "not serious (challenge) at all" or "not an impediment for us" depending on the nature of the specific impediment (Table 4).

The descriptive analysis (mean and SD) of the "seri-

ousness of EDI impediment” variable presented in Table 5 is also useful for clarifying the earlier results. Based on average “seriousness” scores for all impediment items that were not marked as “not an impediment,” the *three most serious* impediments faced by sampled SMEs are “ability to seamlessly integrate existing applications with existing internal applications” (1.96), “learning new technology and methodology” (1.92), and “high startup costs” (1.89). These three impediments are closely followed by a tie between “availability of managerial time to expand EDI use” and “translating customer/supplier data for direct use in internal applications” with an average seriousness score of 1.88.

All the EDI impediments listed in Table 5 received mean “seriousness” scores of greater than 0, indicating that surveyed organizations did encounter these impediments, but with varying degrees of difficulty. It is also interesting to note that the seriousness of all the EDI impediments varies from a low of 1.35 (not serious at all = 1.00) to a high of only 1.96 (somewhat serious challenge = 2.00 and extremely serious challenge =

3.00). This result suggests that a majority of the impediments to EDI adoption and integration faced by the sampled firms are serious, but are not insurmountable challenges.

Hence, it can be concluded that the surveyed firms find the costs for EDI setup and ongoing integration to be high but not prohibitive. Further, SMEs face significant challenges in changing the way they do business while finding managerial time to learn and implement a new technology and trading procedures.

The Structure of EDI Impediments

The EDI impediment items were also further analyzed on the seriousness scale using the “principal components analysis (varimax rotation with Kaiser normalization)” statistical technique.⁷ This exploratory factor analysis was used to identify any underlying factors that

⁷SPSS/PC version 8.0 was utilized for statistical analysis.

Table 5. Seriousness of EDI Impediments (Descriptive Statistics)

EDI Impediments	N	Mean	SD
Ability to seamlessly integrate EDI with existing internal applications	70	1.96	0.82
Learning new technology and methodology	72	1.92	0.69
High startup costs	80	1.89	0.66
Availability of managerial time to expand EDI use	69	1.88	0.78
Translating customer/supplier data for direct use in internal applications	68	1.88	0.70
High cost of integration and expansion of EDI use	74	1.84	0.68
Changing business processes	69	1.80	0.63
Absence of uniform EDI standards	68	1.79	0.74
End users' and customers' continued reliance on paper-based transaction	74	1.77	0.69
Dealing with multiple EDI formats	60	1.77	0.72
Exposure to ever-changing customer/supplier requirements about EDI system	67	1.73	0.66
Implementing multiple trading partners	65	1.72	0.72
Availability of technological resources	72	1.72	0.72
Understanding potential benefits of EDI	71	1.70	0.78
Availability of financial resources	74	1.68	0.70
Complexity of the technology	74	1.66	0.67
Integrating multiple EDI systems and/or VAN connections	57	1.63	0.75
Overcoming resistance to change	67	1.63	0.65
Considering EDI as a natural extension of preexisting internal operations	71	1.62	0.72
Maintaining one system for EDI-capable & another for non-EDI-capable partners	59	1.61	0.72
Managing data and transmission security and auditability	59	1.56	0.62
Increased responsibility for employees	67	1.55	0.61
Obtaining general information about EDI	74	1.54	0.69
Impersonal nature of EDI	56	1.54	0.71
Low volume or frequency of orders	60	1.53	0.79
Determining appropriate internal applications to apply EDI	68	1.49	0.63
Small size of business	60	1.45	0.65
Gaining management/stakeholder commitment	61	1.44	0.59
Addressing legal issues (e.g., electronic orders, signatures, legal agreements)	55	1.42	0.57
Selecting the hardware to run EDI software	61	1.38	0.58
Selecting means for communications with trading partners	65	1.35	0.54

This descriptive analysis of the “seriousness of EDI impediments” variable is based on the following ratings: “not serious at all” (1), “somewhat serious challenge” (2), and “extremely serious challenge” (3).

constitute the "impediments" to EDI adoption and integration construct. An eight-factor structure was found, explaining nearly 71% of the sample variance. Nearly all the "impediment" scale items had a loading greater than 0.5 on the factor to which they were attributed. Nunnally (1978) recommends a 0.5 threshold to achieve an adequate level of reliability for each factor in exploratory work; of the 31 impediment items, five had a score less than 0.5 and all save one had factor loading scores greater than 0.45. Communalities for the eight factors ranged between 0.56 and 0.82 with one exception at 0.49. This is another indication of the validity of the latent factor structure. Further, each of the eight factors has at least three items loading on them. This is in line with the recommendation of some authors (e.g., Kim, 1978; Thurstone, 1947) that in judging the value of a factor analysis it is "more crucial to have at least three variables per factor" than achieving a higher ratio of the number of variables to the number of underlying factors.

The eight categories of EDI impediments found by the factor analysis shown in Table 6 can be described as follows.

- Factor 1 can be named **organizational (business-specific) challenges**, and it relates to the impediments associated with the increased responsibility of employees, changing business processes, resistance to change, size of business, and stakeholder commitment.
- Factor 2 can be named **technology adoption and implementation challenges**, and it relates to the impediments associated with integrating multiple EDI systems and/or VAN connections, dealing with multiple EDI formats, absence of uniform EDI standards, implementing multiple trading partners, and selecting means for communications with trading partners.
- Factor 3 can be named **change management challenges**, and it relates to the impediments associated with understanding potential benefits of EDI, considering EDI as a natural extension of preexisting internal operations, availability of managerial time to expand EDI use, and end users' and customers' continued reliance on paper-based transactions.
- Factor 4 can be named **technology-business integration challenges**, and it relates to the impediments associated with determining appropriate internal applications to apply EDI, translating customer/supplier data for direct use in internal applications, selecting the hardware to run EDI software, and the ability to seamlessly integrate EDI with existing internal applications.
- Factor 5 can be named **trading and communications security challenges**, and it relates to the impediments associated with managing data and transmission security and auditability, dealing with the exposure to ever-changing customer/supplier requirements about EDI system (due to the dependence on the trade linkages), and addressing legal

issues (e.g., electronic orders, signatures, legal agreements).

- Factor 6 can be named **resource challenges**, and it relates to the impediments associated with the availability of financial and technological resources, and the high costs associated with startup, integration, and expansion of EDI use within the firm.
- Factor 7 can be named **education/training-related challenges**, and it relates to the impediments associated with obtaining general information about EDI, learning a new technology and methodology for conducting business, and the complexity of the technology itself.
- Factor 8 can be named **operational challenges**, and it relates to the impediments associated with the characteristics of the specific technology (EDI) itself in the context of its use in small- to medium-sized firms. These attributes include diverse facets such as the impersonal nature of EDI, low volume or frequency of orders, and the difficulty of maintaining one system for EDI-capable and another for non-EDI-capable partners.

CONCLUDING REMARKS

Limitations

As with most research endeavors, the findings reported in this research have some potential limitations. Because the research method for this study is nonexperimental⁸ in nature, study results are not necessarily generalizable to all SMEs. However, the results can be generalized to the industries and organizational characteristics represented by the sample used in this study. Further, although no cause and effect conclusions are drawn, study results lead one to some important conclusions about the characteristics and structure of impediments faced by SMEs implementing advanced information technologies such as EDI.

Implications for Research and Practice

The results of this research study have potential implications for both practice and research. SME owners can derive some consolation in the finding that although firms face many serious impediments to EDI adoption and integration, they are apparently not insurmountable. Also, SME owners can more effectively plan the adoption and/or integration of EDI in their organizations by addressing the critical impediment "categories" identified and clarified in this study. Further, larger trading partner firms (hubs) can also benefit by a better understanding of the kinds of challenges faced by spoke enterprises.

In terms of research implications, the findings of this

⁸An experimental variable (e.g., EDI use or nonuse) is neither introduced nor controlled in nonexperimental research designs.

Table 6. Factor Loadings for EDI Impediment Construct^a

EDI Impediments	Factor ^b							
	1	2	3	4	5	6	7	8
Increased responsibility for employees	0.80							
Changing business processes (new way of thinking about & doing business)	0.66							0.29
Overcoming resistance to change	0.65					0.30		
Small size of business	0.63							
Gaining management/stakeholder commitment	0.57			0.36	0.30			
Integrating multiple EDI systems and/or VAN connections		0.84						
Dealing with multiple EDI formats		0.80			0.27			
Absence of uniform EDI standards		0.77			0.29			
Implementing multiple trading partners		0.63					0.48	
Selecting means for communications with trading partners (e.g., choice of third-party VANs)		0.43		0.32				0.33
Understanding potential benefits of EDI	0.28		0.81					
Considering EDI as a natural extension of preexisting internal operations	0.33		0.80					
Availability of managerial time to expand EDI use			0.52	0.52		0.32		
End users' and customers' continued reliance on paper-based transactions		0.33	0.46		0.39		0.29	
Determining appropriate internal applications to apply EDI				0.72				
Translating customer/supplier data for direct use in internal applications				0.68	0.39			
Selecting the hardware to run EDI software	0.42			0.59				
Ability to seamlessly integrate EDI with existing internal applications	0.39		0.39	0.50				
Managing data and transmission security and auditability					0.82			
Exposure to ever-changing customer supplier requirements about EDI system (e.g., lack of audit trails)		0.43			0.62			
Addressing legal issues (e.g., electronic orders, signatures, legal agreements)			0.42		0.60		-0.28	
Availability of financial resources						0.89		
High startup costs						0.80		
High cost of integration and expansion of EDI use						0.66		-0.25
Availability of technological resources ^c			0.48			0.45		
Obtaining general information about EDI			0.30				0.70	0.29
Learning new technology and methodology (e.g., trading partner's new procedures)	0.34						0.56	
Complexity of the technology				0.47			0.54	0.34
Low volume or frequency of orders								0.81
Maintaining one system for EDI-capable & another for non-EDI-capable partners					0.31			0.60
Impersonal nature of EDI ^d (e.g., lose touch with customers/suppliers)					0.58		0.28	0.42
Eigenvalues	3.4	3.3	2.9	2.8	2.8	2.0	2.1	1.9
% of variance	10.9	21.7	31.1	40.3	49.3	58.0	64.7	70.9
Cronbach's alpha	0.78	0.79	0.81	0.78	0.75	0.76	0.78	0.64
Mean interitem correlation	1.2	1.2	1.5	1.3	1.2	1.6	1.5	1.1

^aRotation converged in 13 iterations. ^bCross-loadings between factors below 0.25 are not shown. ^cAlthough this item has a marginally higher loading on factor 3, it is included under factor 6 because it is conceptually closely related with the other items in the latter. ^dAlthough this item has a marginally higher loading on factor 5, it is included under factor 8 because it is conceptually closely related with the other items in the latter.

study indicate that the "impediments" construct is made of eight latent factors that can be useful in other studies relating to information technology diffusion and/or impact within organizations. Finally, this multifactor construct could also be used as a moderating variable in studying the determinants of relative benefits attainable by the implementation of advanced information technologies such as EDI.

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