EDI in strategic supply chain: impact on customer service

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Abstract:

Many inter-organizational systems are increasingly using electronic data interchange (EDI) to support the strategic supply chain by way of delivering and processing business documents. In a vendor–customer relationship, EDI can provide many benefits to both organizations; one such benefit is improved customer service. This study examines the impact of EDI on customer service, when the vendor and customer utilize EDI in their distribution operations. The primary hypothesis is that EDI improves customer service. A number of secondary hypotheses dealing with specific components of customer service were also tested. Data was obtained by administering survey instruments to purchasing managers of firms in the automobile and pharmaceutical industries.

The results provide strong support for most of the hypotheses. Specifically, EDI contributes to the following customer service components: order cycle time, product availability, distribution flexibility, distribution information, and distribution malfunction. An impact on post-sale product support was not discernible from the data. In addition, some industry influences were also observed on the impact of EDI.

Keywords: Electronic data interchange (EDI); Inter-organizational systems; Distribution/logistics; Survey research/ design

Article:

1. Introduction

Electronic data interchange (EDI) is a rapidly growing technology, even though it has been widely available since the beginning of the 1980s. The number of registered EDI users, according to *EDI Yellow Pages International*, has shown impressive gains in the past several years, well in excess of a 50% annual growth rate. Among the many benefits of EDI are: faster processing speed, greater accuracy, reduced costs, competitive advantage, improved operations, security, tracking and control, intra and inter company communications, and customer service (Craig, 1989; Gourley, 1998; Hansen & Hill, 1989; Kimberley, 1991; Mele, 1999; Richardson, 1988). Due to its capabilities to support inter-organizational systems, EDI has made a special contribution to the strategic supply chain of companies. One important aspect of the supply chain is the customer–supplier relationship. In this article, we focus on EDIs impact on "customer service". It should be noted that many other benefits of EDI manifest into customer service. For example, customer service offers a powerful basis for establishing competitive advantage (Jackson, Lewis, & Cannon, 1991; Kyj & Kyj, 1989). Customer service may also represent the best opportunity for a firm to increase its market penetration and profitability (Lambert & Harrington, 1990).

EDI can have significant bearing on customer service. EDI provides a faster, more accurate, and less costly method of communication with customers compared to other methods, such as mail, telephone, and personal delivery (Crum, Johnson, & Allen, 1998; Emmelhainz, 1989). Iacovou, Benbasat, and Dexter (1995) insist that integrated EDI systems increase customer service in addition to operational efficiency. One should be careful in sweeping generalizations, however. For example, EDI may weaken the level of customer service due to the

locking of a buyer into a very limited number of suppliers and subsequent pressures on the suppliers (La Londe and Emmelhainz, 1985; Sokol, 1989; Suzuki & Williams, 1998). In any case, the various pronouncements of EDIs impact on customer service are based on rhetorical power and anecdotal evidence, and need to be investigated in detail and with rigor.

2. EDI and customer service: background and a model

2.1. Definition of EDI

Crum et al. (1998) describe EDI as "the direct computer-to-computer communication of inter-company and intra-company business documents in a machine-readable standard format". The inter-organizational aspect of EDI has received much attention. For example, Hill and Swenson (1994) emphasize the role of EDI in the electronic exchange of information between business partners in a structured format. EDI can be distinguished from other forms of electronic communication, such as fax and electronic mail, as variations of forms, from unstructured to highly structured (Hansen & Hill, 1989).

This study is concerned with the inter-organizational use of EDI in the strategic supply chain. Accordingly, EDI in this study is limited to the computer-to-computer exchange of machine readable business documents *between* organizations (e.g., the vendor and the customer organization) in a standard format.

2.2. Definition of customer service

In their two books, La Londe and Zinszer (1976), La Londe, Cooper, and Noordewier (1988), developed standards to measure customer service. While customer service is defined differently in different disciplines, La Londe et al. (1988) synthesize three aspects of customer service. First, in an organizational context, customer service is defined as a set of functions, such as the customer service department, which is responsible for all service operations. Second, customer service is defined as performance expectations, for example, "deliver 99% of orders within 10 days". Finally, customer service is defined as "a process for providing significant value-added benefits to the supply chain in a cost effective way".

The last "process" definition is particularly applicable to inter-organizational customers. An effective way to evaluate customer service, therefore, is by way of the performance and outputs of the various logistics processes in the distribution of products. The process view has a good amount of literature support (Williamson & Bloomberg, 1990; O'Neil & Iveson, 1991; Jackson et al., 1991; Stock & Lambert, 1987; Lambert & Harrington, 1990).

2.3. EDI and customer service

Intense competition in the business world, both domestic and international, has made customer service an important element for gaining strategic advantage (Dadzie & Johnston, 1991). IT plays an increasingly vital role in this regard. Sophisticated information systems can differentiate products or services through customer service, while simultaneously strengthening customer ties (Abend, 1998; Learmonth & Ives, 1987; Porter & Millar, 1985). Publicized examples of strategic information systems for competitive advantage (e.g., American Hospital supply, American Airlines, American Express, etc.) capitalize on customer service for maintaining a captive customer base. EDI is another weapon in the IT arsenal. It is already providing unsurpassed levels of customer service to its users, e.g., in transportation/logistics and finance (Ferguson & Hill, 1989; Mukhopadhyay, Kekre, & Kalathur, 1995; Kahn & Mentzer, 1996; Varney & McCarthy, 1996). EDI has the potential to impact many aspects of customer service, as will be discussed later.

2.4. Customer service support system model with EDI

Fig. 1 depicts a conceptual model of inbound logistics from an organizational customer's perspective, when the customer receives service aided by EDI. A more general logistics model would include the acquisition of materials, manufacturing, and distribution to the end users (i.e., customers). Because this study is concerned primarily with the firm and its supplier, only inbound logistics is discussed.

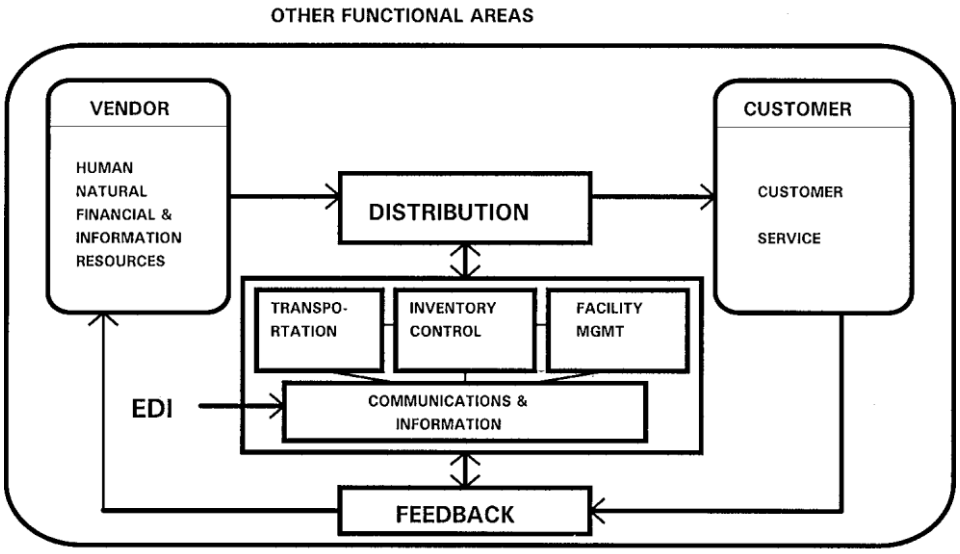

Fig. 1. Customer service support system model with EDI.

The conceptual model, based on general systems theory, consists of four major components: inputs, procedures, outputs, and feedback. The inputs are: human resources, natural resources (land, facilities, equipment, etc.), financial resources, and information resources (Stock & Lambert, 1987). One of the information resources is EDI. The output that we focus on is customer service. Several studies (Williamson & Bloomberg, 1990; O'Neil & Iveson, 1991; Sterling & Lambert, 1989) maintain that the output of logistics is primarily defined by customer service. The physical distribution or logistics is concerned with the flows of finished goods from the production line to the customers, and that the right product is delivered to the right customer in the right place and at the right time. Accordingly, customer service depends on these aspects of logistics.

Distribution operations include request for quote, purchase order, acknowledgement of purchasing order, status request/response, shipping notice, physical delivery of product, and invoice. On the other hand, feedback is related to post-transaction activities. If the right product or service is not delivered to the right customer at the right place or right time, feedback is needed for adjustments, returns, or reorders. Feedback is also necessary for technical advice and maintenance.

Communication and information are required in both distribution and feedback activities. EDI serves as a major conduit for the flow of information between an organizational customer and vendor; thus, it may have a significant impact on customer service. We examine this impact in greater detail.

3. Research model and design

A research model was developed to investigate the impact of EDI on customer service in an inter-organizational context (Fig. 2). The independent variable is the level of EDI integration in inter-organizational transactions between customer and vendor organizations. It is measured at four levels. The dependent variable is customer service as provided by the vendor to the customer organization. Customer service is divided into six components (La Londe & Zinszer, 1976; La Londe et al., 1988). The primary control variable is "industry". The effect of several other moderating variables, e.g., size of company, and geographic area, is also investigated in order to trace any systematic bias (Venkatraman & Zaheer, 1990).

3.1. Independent variable

The independent variable is the level of EDI integration into the customer organization. The integration level will impact the level of benefits. For example, if an organization has stand-alone systems, it will incur costs as information will have to be rekeyed into another computer after the document is printed from the stand-alone system. However, if the EDI systems are fully integrated, the level of benefit will be presumably very high (e.g., when EDI is fully integrated into a "just-in-time JIT" system).

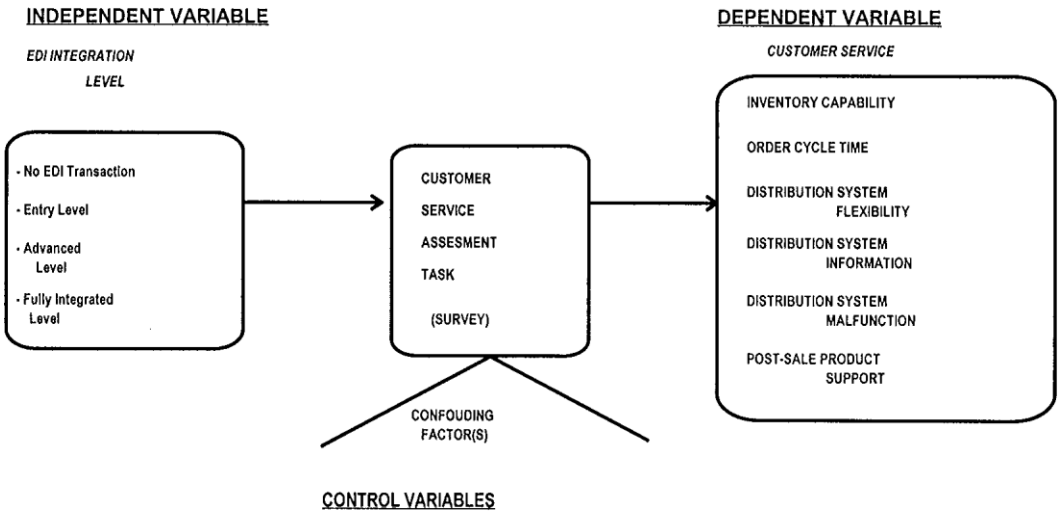

Fig. 2. Explanatory model.

Witter (1990) has defined three EDI levels based on performance and degree of integration. The three levels of EDI are categorized by the degree of top management commitment, number of transactions through EDI, number of EDI trading partners, and hardware configurations. The levels are: entry level, advanced level, and fully integrated level. Kahn and Mentzer (1996) also specified three levels: the lowest (stand-alone EDI), the middle (application integration EDI) and the highest (process reengineering EDI). In the lowest level, a company does not integrate EDI into any of its internal processes. In the middle level, EDI is integrated into some of the applications so that demand information is transferred automatically to the supplier. In the highest level, EDI transactions are integrated into many applications, including some automatic forecasting functions.

In this study, EDI levels are categorized based on the above studies. In addition to the three levels, one more level has been added. This is “no EDI transactions”, and includes companies which do not have EDI transactions currently or may have plans only in the future.

3.2. Dependent variable

The logistics process can be evaluated by examining different activities. Williamson and Bloomberg (1990) used 23 detailed activities from five major business functions: transportation, facility structure, material handling, information, and communication. Lambert and Harrington (1990) identified 23 variables, and La Londe et al. (1988) identified 6 major variables with 24 detailed items for manufacturing and merchandising.

With our focus on manufacturing and merchandising industries, six variables proposed by La Londe et al. will be used to measure customer service. These are: *inventory capability*, *order cycle time*, *distribution system flexibility, distribution system information, distribution system malfunction, and post-sale support*. Specific items, proposed by La Londe et al. (1988), Williamson and Bloomberg (1990), Lambert and Harrington (1990) were further modified by information obtained from interviews conducted prior to the pilot survey. A 7-point Likert-type scale was used to measure each item.

The summary of the variables and items is listed in Table 1.

3.3. Control variable

The primary control variable is industry. There may be systematic differences in customer service due to EDI between industries. Although EDI is computer-to-computer communication in a standard format, a standardized form is not available for all industries. Most EDI systems are industry specific. For example, ORDERNET is a major EDI system in the healthcare industry, UCS (Uniform Communication Standard) is the data standard in the transportation industry, and ANSI X.12 is popular in the automobile industry. Furthermore, different industries exhibit different customer service characteristics and requirements. Two industries are investigated: automobile and pharmaceutical. This selection is based on the fact that both industries are major users of EDI.

Table 1
Customer service variables and items

Product availability
Average order fill rate of line items
Meeting promised delivery date
Order cycle time
Average order cycle time
Final delivery time on orders past due
Distribution system malfunction
Accuracy of billing
Accuracy of delivering the right product
Distribution system flexibility
Ability to expedite shipments
Ability to handle special shipping instructions: reconsignment
Distribution system information
Notice of price change
Notice of new product information
Notice of shipping delay
Availability of order status information
Post-sale product support
Time to take corrective action on complaints
Average response time to a request for technical advice or maintenance information

3.4. Moderating variables

There are other variables that may have an impact on customer service. The effect of these variables will be evaluated before the full-scale analysis. The variables to be considered are: company size and location (urban vs. rural). Company size may have relevance because of the differences in resources, flexibility, strategies, etc. between large and small companies. Location may have an influence as the technology infrastructure and service requirements may vary by location.

3.5. Research design

A 2 x 4 factorial design was developed (Fig. 3). The primary variable is EDI integration, which has 4 levels. The control variable "industry" is explicitly built into the research design and has two levels: automobile and pharmaceutical industries. The response variable is customer service, which has six components.

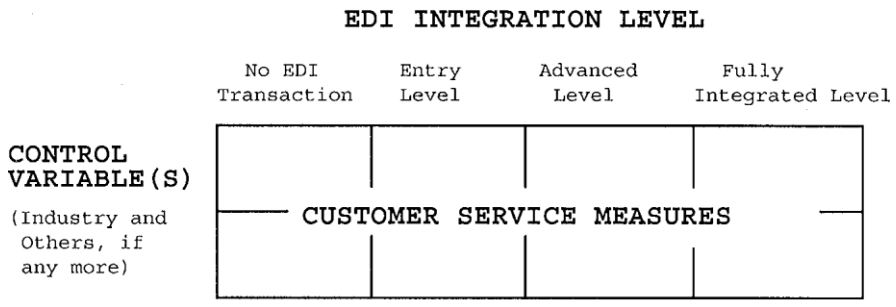

Fig. 3. ANOVA design.

4. Research hypotheses

The expected relationships are summarized in the following hypotheses. These hypotheses are a reflection of the prevailing statements in the literature on EDIs benefits, although they are mostly unsubstantiated. All hypotheses are expressed in the alternative form. The primary hypothesis is:

H_a: The level of EDI integration into an organization will have a positive impact on customer service.

Customer service has been listed as one of the many benefits of using EDI in inter-organizational systems. The literature provides many examples to support EDIs impact on customer service. In fact, Hansen and Hill (1989) have ranked customer service as the top benefit due to EDI.

There are six sub-hypotheses related to each component of customer service:

H_{1a}: The level of EDI integration into an organization will have a positive impact on inventory capability.

Inventory capability refers to product availability from the vendor when the product is demanded by the customer organization. Numerous ways exist to measure inventory capability. The major measurements of inventory capability or product availability include: average order fill rate of line items eventually completed, average order fill rate of cases eventually shipped, and performance in meeting the promised delivery date. Inventory capability may be enhanced by EDI, because EDI improves the accuracy and timeliness of information needed to maintain proper levels of inventory. Boland (1989) states that EDI provides a highly coordinated supply chain and reduces inventory level by closely monitoring line conditions. Per Andel (1996), customers can optimize inventory requirements by suitably arranging the vendor's shipments and reconfiguring purchase orders.

H_{2a}: The level of EDI integration into an organization will have a positive impact on order cycle time.

Total order cycle time is the time from when a customer organization places an order to when it is received. One of the major determinants of customer service is the provision of fast service. The electronic speeds with which the various phases of the order process (e.g., placing the order, order confirmation, problem order resolution, shipment notice, order delivery, etc.) can be executed, has the potential of significantly reducing this time. In fact, the reduction of processing time between order placement and order delivery is one of the primary reasons for introducing EDI (Hansen, 1989; Snapp, 1990; Kimberley, 1991; Iacovou, 1995).

H_{3a}: The level of EDI integration into an organization will have a positive impact on distribution system flexibility.

Flexibility in distribution is needed so that unexpected situations, such as strikes, uneven demand and shortages, do not interrupt the product flow. Measurements of distribution system flexibility include ability to handle special shipping instructions, requests to expedite shipment, specific carrier selection instructions, etc. EDI makes it easy to access such information (Ferguson, 1989; Maaren, 1989; Hansen & Hill, 1989) and quickly take necessary actions. Thus EDI may provide more flexibility (Horan, 1989; Brill, 1986).

H_{4a}: The level of EDI integration into an organization will have a positive impact on distribution system information.

Quality information is vital in distribution/logistics operations. An EDI-based information system can provide accurate and timely information to all, i.e., the shipper, third party, and consignee (La Londe et al., 1988). Distribution system information is concerned with accuracy as well as how far in advance an organization notifies its customer organizations of important product related events, such as price change, new product information, old product cancellations, shipping delays, and order status. It has been argued that the use of EDI can improve both the accuracy of processing and information quality (Horan, 1989; Craig, 1989; Boland, 1989; Hill & Swenson, 1994; Iacovou et al., 1995).

H_{5a}: The level of EDI integration into an organization will have a positive impact on distribution system malfunction.

A distribution system malfunction occurs when the wrong product is delivered, or the product is delivered to the wrong customer, to the wrong place, or at the wrong time. Furthermore, the billing information may be

incorrect or not sent to the right organization. These malfunctions should be corrected as soon as possible, and the vendor organization's ability to remedy these is very important to the customer. Because of paperless handling and better quality information, malfunctions are expected to decline. Snapp (1990) states that EDI improves accuracy because there is no need to rekey the information. Another example is when EDI combined with bar coding products or shipping cases allows for faster reconciliation of invoices (Boland, 1989). To measure distribution system malfunctions, two items are included: accuracy of billing, and accuracy of delivering the right product (i.e., accuracy in filling orders).

H_{6a}: The level of EDI integration into an organization will have a positive impact on post-sale product support.

Customer service activities, which follow the sale, are supportive of the product once it has been put into use. This is essential in building customer confidence, vendor reputation, and repeat business. Functions of post-sale support include product warranty, alterations, parts and repair services, and provision of product usage information. The two major elements used to measure post-sale product support include: time to take corrective action on complaints, and the average response time to a request for technical advice or maintenance information. EDI has the potential to improve post-sale support by virtue of its ability to provide fast and error-free information. The ability to link relevant pieces of information across various systems, databases, and organizations further enhances this capability.

5. Methodology

A cross-sectional survey of organizations at various phases of EDI integration with their vendors was conducted. Each organization was treated as customer, and was to provide information on its relationship with the vendor in terms of customer service. An instrument was designed which measured customer service and its components using the validated items developed by La Londe et al. (1988). Each component is measured by the sum of the scores on its constituent items. Overall customer service is measured by the sum of the scores on all 14 items. The questionnaire also ascertained the organization's level of EDI integration by providing specific criteria. Demographic questions about the customer and vendor organizations were also included.

A pilot study was conducted. Based on the pilot, minor changes to demographic questions and some cosmetic changes were made. None of the variables or the items were changed. Given these minimal changes and the fact that the final survey was conducted just a few weeks after the pilot, the pilot responses are included with the full study.

In the final survey, stratified random sampling was used, i.e., a random sample from each of the two industries was selected. Two hundred and fifty companies were randomly selected nationwide from each industry. They were called by phone to find a purchasing or purchasing related manager and to ask for cooperation in the study. Lambert and Harrington (1990) insist that one of the best methods to get high response rates is telephone calls in advance. During the telephone calls, four more subjects were added to the samples. Finally, 504 companies were contacted: 251 pharmaceutical and 253 automobile companies. All 504 managers were called three times until they responded. Questionnaires were sent to only those who agreed to complete them. Repeated mailings were made to those who did not respond. Of the 167 managers that were contacted in this manner, 106 eventually completed the questionnaire. This yielded a very high response rate of 63.5%.

Seventy-one additional questionnaires were sent without first calling the people by phone. Only 8 responded, yielding a response rate of 11.3%. Total number of completed questionnaires is 114, and the overall response rate is 47.9%. The industry breakdown was: 61 responses from the automobile industry and 53 from the pharmaceutical industry.

The "pre-screening of respondents by telephone calls" method of surveying, although expensive, generates significantly higher response rates and provides superior data. We highly recommend it.

6. Results

6.1. Sample characteristics

Our sample was nationwide in the United States. Responding subjects were distributed in 36 states, the highest frequency being 12 in California. Most of the other states included one to five subjects. Thus we had a fairly good representation of all regions of the country.

There were four EDI integration levels from No EDI to Fully Integrated Level. Among the respondents, 59 out of 114 were in the stage of No EDI. The rest (55 out of 114) had some kind of EDI capability (see Fig. 4).

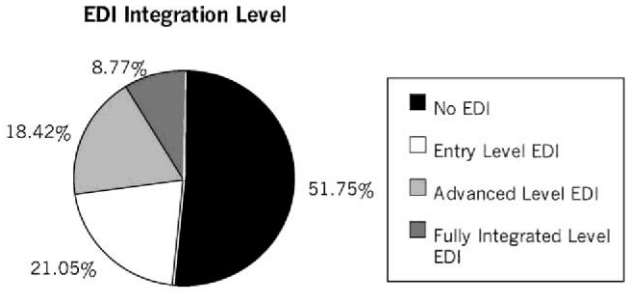

Fig. 4. EDI integration level.

6.2. Instrument reliability

The reliability of the instrument can be measured in several ways. One is to measure its consistency over time (Alreck & Settle, 1985). While not exactly the same as test–retest reliability, it is similar. The data for this study were collected in four different times: pilot study, first mail, second mail, and third mail. It took about a 3-week period of time for each data collection. There is a possibility of bias due to the different time intervals, and data consistency over time may not hold. Armstrong and Overton's "panel of experts" methodology (Lambert & Harrington, 1990) was used to check the consistency. Accordingly, the mean scores at different times are compared. No difference among the group mean scores implies that there is no such bias. A one-way ANOVA was used. The F-statistic is not significant at the 5% significant level, implying that there is no systematic time effect.

A standard and accepted way of evaluating reliability is to compute and examine the reliability coefficient (Cronbach's α). The reliability coefficient for the total 14 items was 0.92. McMillan and Schumacher (1989) suggest that an acceptable range of reliability for coefficients for most instruments is between 0.70 and 0.90. Therefore, our instrument is highly reliable.

6.3. Revisiting the independent variable

While the four levels of EDI integration are based on previous articles, these levels were deemed somewhat arbitrary by purchasing managers in our initial interviews. The category was reexamined before the full-scale analysis started. Each pair in the four groups was examined. The two levels in each pair were compared in terms of overall customer service with a t-test. All of the significant results were obtained for pairs between the No EDI and other groups. The three pairs involving integration, i.e., entry level, advanced level, and fully integrated level, did not differ significantly. Therefore, the independent variable was regrouped into two levels: *No EDI* and *EDI*. EDI now includes the three previous levels of integration. This recategorization also increased the sample size of the two groups, i.e., 59 and 55, thus increasing the power of all subsequent tests.

6.4. Examination of moderating variables

Before a full-scale analysis, the moderating variables were examined to evaluate their impact on customer service. The moderating variables are: relative size of the company in relation to the vendor, and urban/rural location of the company. In a similar vein, Venkatraman and Zaheer (1990) used company size, and location (metro or small city, etc.) as factors in their study on electronic integration.

For the two variables, two-way ANOVAs were performed to find whether the company size or rural/urban location had an affect on customer service. None of them had a significant result. These tests allowed us to proceed with the full-scale analysis without having to be concerned about these variables.

6.5. Hypotheses testing

All test results are summarized in Table 2. Each specific hypothesis is discussed below.

Table 2
Summary of ANOVA for hypothesis testing

Source of variation	Sum of squares	DF	Mean square	*F*	Sig of *F*
Main hypothesis					
H_{0a}: accepted					
Main effects	2031.690	2	1015.845	7.050	0.001
EDI	1675.767	1	1675.767	11.630	0.001
INDUSTRY	326.728	1	326.728	2.267	0.135
Interaction	531.515	1	531.515	3.689	0.058
Residual	14985.758	104	144.094		
Total	17548.963	107	164.009		
Sub-hypotheses					
H_{1a}: accepted					
Main effects	29.446	2	14.723	4.197	0.018
EDI	28.721	1	28.721	8.188	0.005
INDUSTRY	0.428	1	0.428	0.122	0.728
Interaction	9.734	1	9.734	2.775	0.099
Residual	378.820	108	3.508		
Total	418.000	111	3.766		
H_{2a}: accepted					
Main effects	31.646	2	15.823	3.434	0.036
EDI	31.599	1	31.599	6.858	0.010
INDUSTRY	0.000	1	0.000	0.000	0.996
Interaction	24.104	1	24.104	5.231	0.024
Residual	488.441	106	4.608		
Total	544.191	109	4.993		
H_{3a}: accepted					
Main effects	34.824	2	17.412	3.545	0.032
EDI	30.714	1	30.714	6.253	0.014
INDUSTRY	3.509	1	3.509	0.714	0.400
Interaction	8.340	1	8.340	1.698	0.195
Residual	525.611	107	4.912		
Total	568.775	110	5.171		
H_{4a}: accepted					
Main effects	228.561	2	114.281	5.313	0.006
EDI	191.635	1	191.635	8.909	0.004
INDUSTRY	33.700	1	33.700	1.567	0.213
Interaction	19.111	1	19.111	0.888	0.348
Residual	2280.046	106	21.510		
Total	2527.718	109	23.190		
H_{5a}: accepted					
Main effects	32.659	2	16.329	4.907	0.009
EDI	21.329	1	21.329	6.409	0.013
INDUSTRY	10.202	1	10.202	3.066	0.083
Interaction	1.350	1	1.350	0.406	0.526
Residual	359.420	108	3.328		
Total	393.429	111	3.544		
H_{6a}: rejected					
Main effects	35.729	2	7.864	2.545	0.083
EDI	22.557	1	22.557	3.213	0.076
INDUSTRY	12.205	1	12.205	1.739	0.190
Interaction	24.764	1	24.764	3.528	0.063
Residual	751.092	107	7.020		
Total	811.586	110	7.378		

6.5.1. Main hypothesis on overall customer service

H_a: The level of EDI integration into an organization will have a positive impact on customer service.

A two-way analysis of variance was conducted to test the hypothesis. Table 2 shows the ANOVA results. EDI integration level and industry do not interact at the 5% level of significance. Also, industry has no effect on overall customer service.

The EDI main effect is significant at the 1 % significance level. Additionally, the relationship between EDI and customer service is positive. Thus the main hypothesis is strongly supported. Along with many researchers, Hansen and Hill's study (1989) supports this result. They found that the first ranked benefit of EDI was "customer service" with a 4.25 average on a 5-point scale, with "5" being the most important.

In order to provide further insights, we now examine EDIs impact on the individual components of customer service.

6.5.2. Sub-hypothesis on inventory capability

H_{1a}: The level of EDI integration into an organization will have a positive impact on inventory capability
There is no significant interaction between EDI integration and industry at a 5% significance level. Also, the EDI main effect is significant at the 1% significance level, strongly supporting the hypothesis. The industry main effect is not significant.

The positive relationship between EDI integration and inventory capability indicates that EDI-integrated organizations get better performance from their vendors than the non-EDI organizations in terms of product availability and delivery. The speedy and accurate processing provides flexibility in inventory control, making sure that the products are available as and when needed by the customer. This may also result in reduced levels of inventory. One of the major reasons for high inventory is uncertainty in the distribution channel. EDI reduces this uncertainty by providing accurate information rapidly to all concerned parties.

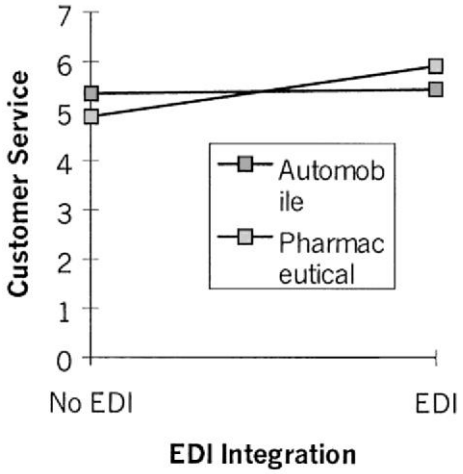

Fig. 5. Interaction by industry.

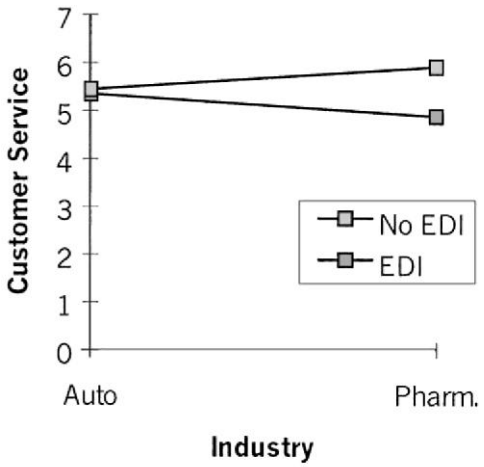

Fig. 6. Interaction by EDI integration.

6.5.3. Sub-hypothesis on order cycle time

H_{2a}: The level of EDI integration into an organization will have a positive impact on order cycle time.

ANOVA tests indicate a significant interaction (at the 5% level) between the two independent variables. Figs. 5 and 6 show where the interaction is located. In Fig. 5, the two industries intersect each other. In Fig. 6, the two EDI groups do not cross each other. Thus, the interaction is primarily caused by the industry variable.

The EDI main effect is significant at the 1 % level. There is a significant difference in order cycle time between EDI-integrated and Non-EDI organizations; the average score in EDI-integrated organizations is much higher than the score in non-EDI organizations. The result confirms our expectations as the electronic communication

enabled by EDI is many times faster than other forms of communication, and communications delays are a significant portion of the order cycle time.

6.5.4. Sub-hypothesis on distribution system flexibility

H_{3a}: The level of EDI integration into an organization will have a positive impact on distribution system flexibility.

This hypothesis is accepted at the 5% significance level. Further, there is no indication of interaction between the independent variables, nor there is a significant industry main effect. The results indicate that EDI makes product flow and ordering process flexible. This, in turn, would contribute to improving customer service. Flexibility is needed between two trading partners.

Unexpected situations would require changes in product flow, e.g., expediting of orders, changes in shipping instructions, changes in order information, etc. The close relationship between the vendor and the customer, fast and accurate processing of information, and standardization of system interfaces, all made possible by EDI, makes the distribution system more flexible.

Wigglesworth (1989) has described one EDI benefit as operational flexibility. He claims that flexibility is achieved through a reduction in paperwork and standardization of procedures. Flexibility in turn improves customer service and generates customer loyalty and goodwill.

6.5.5. Sub-hypothesis on distribution system information

H_{4a}: The level of EDI integration into an organization will have a positive impact on distribution system information.

This hypothesis is accepted at the 1% significance level. There is no indication of interaction and industry by itself does not have a significant effect on this aspect of customer service.

The major differences between EDI and conventional communication systems are: accurate and fast communications, direct access to the vendor's database (due to standardization affected by EDI interfaces), and the integration of the EDI system into other systems within an organization. Consequently, an EDI system provides faster and more accurate information to the customer on various aspects of distribution and logistics, e.g., price changes, product changes, order status and shipping details. Boland (1989) has stated that the ability of suppliers to respond to manufacturers' changing production requirements — and in turn for manufactures to respond to changes in the marketplace — depend on fast, error-free EDI transmission of information.

6.5.6. Sub-hypothesis on distribution system malfunction

H_{5a}: The level of EDI integration into an organization will have a positive impact on distribution system malfunction.

This hypothesis is accepted at the 5% level. There is no interaction between EDI integration and industry. The industry main effect is also insignificant. *Distribution System Malfunction* is mainly related to the accuracy and speed of billing and the accuracy of delivering the right product. It is not uncommon for products to be delivered to the wrong place or at the wrong time because of erroneous communications. The use of EDI reduces these problems (thus also diminishing re-keying processes and additional paperwork). One major benefit of EDI is improved accuracy (Craig, 1989; Kimberley, 1991), which in turn leads to fewer problems in the distribution chain. Boland (1989) has said that EDI helps manufacturers and distributors make their suppliers more accountable by providing better information up front on production schedules and orders. Specifically, it is very difficult to implement just-in-time (JIT) manufacturing with a frequently malfunctioning and erroneous distribution system. Schatz (1986) has even said: "No JIT without EDI". Thus, EDI has a major role to play in an automated, accurate and speedy system that diminishes distribution malfunctions.

6.5.7. Sub-hypothesis on post-sale product support

H_{6a}: The level of EDI integration into an organization will have a positive impact on post-sale product support.

The Post-Sale Product Support hypothesis is not supported at the 5% level. In fact, it is the only hypothesis that was not supported. In other words, the effect of EDI on post-sale support cannot be established based on our data.

To gain insights into this apparent anomaly, a purchasing manager in an automobile parts company was interviewed and was asked how the company responded to its vendors after sales were incorrectly made. It was revealing to know that if the vendors sent the wrong product, or to the wrong place, the customer organization communicated by telephone and facsimile, rather than EDI. Two more purchasing managers in the pharmaceutical area responded in a similar manner. After something went wrong in the delivery of orders, they first called on the telephone to discuss it, and then asked the vendor's customer service department to solve the problem. This indicates that EDI systems are not being used effectively in solving problems related to post-sale product services.

7. Discussion and implications

We discuss several areas where our findings have implications. First, while EDI technology has been available for well over a decade and many organizations have aggressively pursued it, many others have been slow and cautious in its adoption (Suzuki & Williams, 1998). The benefits of EDI are based on logical and rhetorical arguments, but the evidence has been largely anecdotal. Empirical evidence has been simply slow in coming. We provide solid empirical evidence on one of the impacts of EDI, i.e., customer service. The evidence is overwhelming in favor of EDI. Organizations that regard customer service as crucial should be heartened by these results, and may wish to investigate investment into EDI technology.

Second, while we found evidence of improved customer service in both industries, we could not observe differences between the two industries. Thus, while the positive impact of EDI could be generalized on more industries, we cannot make any definitive statement on the degree of impact based on industry. This issue requires further research and analysis. Our lack of finding a difference may have been based on our selecting just two industries and the nature of the selected industries. Furthermore, even in our data, industry differences were observed on "distribution malfunction" at a higher level of significance ($p = 0.083$), and couple of EDI–industry interactions were also significant at somewhat higher p values. These patterns suggest the need for further study.

Our third observation is that the impact of EDI is different on different components of customer service. As noted earlier, hypotheses H_{1a}, H_{2a}, H_{3a}, H_{4a}, and H_{5a} were supported at different levels of significance. In fact, hypothesis H_{6a} (impact on post-sale support) was not supported at all. This finding may be interpreted in one of two ways. First is the obvious one, which is that all components do not benefit equally from EDI (Suzuki & Williams, 1998), and management may use EDI selectively on components that promise most improvement. The second interpretation calls for management responsibility. Management may not assume automatic benefits in all areas of customer service, but may have to take requisite steps in order to effectuate desired improvement.

Fourth, the results are applicable to several functional areas, e.g., purchasing, logistics, and marketing. Different components of customer service have varying degrees of relevance to the functional areas. For example, in purchasing, the study demonstrates that EDI technologies will reduce the order cycle time and permit the organization to operate at reduced safety stock levels. In logistics and manufacturing, EDI is recognized as an essential information technology (Gourley, 1998; Schatz, 1988). No JIT (just-in-time system) can be implemented without EDI, as system malfunctions and delays in product delivery simply cannot be tolerated. In marketing, an important goal is to make sure that customers are provided excellent service and are satisfied with the products and services. Our results indicate that EDI provides positive impact on customer service, including five of the six customer service components. The multi-functional broad-based impact of EDI should be a positive influence in its adoption.

8. Conclusions

Our empirical investigation provides strong evidence of a positive relationship between use of EDI and improved customer service. Specifically, five of the six components of customer service showed marked improvement with the use of EDI. Additionally, while specific industry effects were not observed, such possibilities exist for future exploration.

The limitations of the study include those associated with survey methods. However, we took the necessary precautions and used the control variable of industry to increase generalizability. The results should instill more confidence in top executives and functional managers in decisions relative to the implementation of EDI. Management support is crucial to implementing EDI (Emmelhainz, 1986; Hoogeweegen, Streng & Wagenaar, 1998). Armed with empirical evidence from other organizations, senior management should be more willing to support and champion EDI projects.

This study also points to the need for further research. While we examined customer service, future researchers may wish to explore EDI impacts on other components of the value chain. Another fruitful avenue of research will be to investigate other factors that influence the adoption and success of EDI. While we explored the industry factor, others need to be explored in future studies.

Finally, as a concluding note, the study has provided empirical validation to the many EDI claims made in the literature. As Gene A. Nelson at Cincinnati Bell Information Systems said:

> Increasing numbers of business in the 1990s will be faced with an ultimatum: adopt Electronic Data Interchange or suffer the effects of disorganized, inefficient environment. In other words, EDI or D.I.E.! (Kirkley, 1992).

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