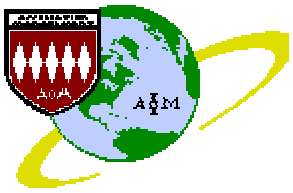

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NEW DIRECTIONS FOR RESEARCH IN ELECTRONIC DATA INTERCHANGE (EDI)

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ABSTRACT

Electronic Data Interchange was envisioned as the future for business with its ability to lower costs, improve productivity, and decrease transaction times. The adoption of EDI has been very slow compared to other information technologies. This article develops a framework to explain why this has occurred. Uncertain economic benefits and the costs of implementing ever-changing EDI standards are shown to be major reasons. In addition, it also proposes directions for future trends and research in EDI.

INTRODUCTION

The history of Electronic Data Interchange (EDI) is filled with overly optimistic predictions on how fast EDI will be adopted by organizations and its impact on organizations [31]. It is our belief that a better understanding of EDI adoption can be developed by examining the findings of research in standards, inventory theory, and diffusion of innovation and by applying these findings to EDI. This will help us understand the reasons for the incorrect predictions related to adoption and impacts on organizations.

EDI was developed in the 1960's to help organizations interact more economically with their channel partners. This is done through the electronic transfer of documents from one company to another. Hopefully, this would reduce transaction times, reduce errors, and reduce labor. It was expected that many if not most business would be using EDI in the near future. Nearly 30 years later, less than 5% of businesses have implemented EDI with most of those occurring in the decade of the 90's [15]. Existing research does not explain why EDI has had such a low adoption rate.

Also, the structure of EDI has changed over the last 30 years. Initially, it was implemented in a hub and spoke system using proprietary software. Later, industries developed standards that enabled trading partners to use their EDI infrastructure across firms with the expectation of lower costs and increased adoption rates. Eventually, national and international standards were developed in the hope of increasing EDI usage. These changes have had some affect on the adoption rate, although implementation has fallen short of predictions. Research is needed to explore new methods of implementing EDI based on newer technologies that would enable more organizations to implement EDI economically.

This paper proposes to both develop a better understanding of the adoption of EDI and to explore new

approaches to EDI. It starts off with the basics of EDI where we describe the EDI concept, its history, and the basics of EDI standards. The next section describes how EDI has been implemented and its adoption rate. In this section we use diffusion of innovation methods to uncover factors that are important to explaining the slow adoption rate for EDI. We then use these findings to explain shortcomings in current justification models, and develop a framework for a more complete model. We also discuss opportunities for reducing the implementation cost of EDI based on current and future directions in information technology. We conclude with a discussion on the future of EDI research.

BACKGROUND ON EDI

EDI Basics

EDI is a subset of electronic commerce (EC) which is broadly defined by Kalakota and Whinston [15] as "a modern business methodology that addresses the needs of organizations, merchants, and consumers to cut costs while improving the quality of goods and services and increasing the speed of delivery." Electronic commerce is also described as the "paperless exchange of business information using Electronic Data Interchange (EDI), Electronic Mail (E-mail), computer bulletin boards, Fax, EFT and other technologies" [20].

EDI, like EC, is both a business process and a technology [21]. Emmelhainz [10] defines EDI as "the interorganizational exchange of business documentation in structured, machine-processable form." Sokol [27] describes EDI as "the intercompany computer-to-computer communication of standard business transactions in a standard format that permits the receiver to perform the intended transaction." Both of these definitions include the concept that EDI is an Interorganizational System (IOS) and involves the exchange of business documents in an electronic format [4]. EDI is a subset of EC which includes other technologies such as E-mail and EFT and is only between businesses and does not involve consumers directly.

Emmelhainz [10] continues her description of EDI to state that the true goals of EDI are not just to replace "manual data entry with electronic data entry" but also to reduce processing delays. Scala and McGrath [25] provide a list of 10 advantages of using EDI. These are shown in Table 1. Not all of the advantages listed are unique and it appears that they can be condensed to four main categories of advantages. The categories are reducing costs, reducing errors, improving relationships, and improving service.

Table 1 Top Ten Advantages of Using EDI (in order of preference)

1.	EDI improves the accuracy of information and reduces errors.
2.	EDI reduces data entry.
3.	EDI speeds the transmissions of information between organizations.
4.	EDI reduces inventory and inventory carrying costs.
5.	EDI enhances our relationship with customers and suppliers.
6.	EDI complements and enhances our company's marketing effort.
7.	EDI improves productivity.
8.	EDI reduces the paper flow between organizations.
9.	EDI standardizes programs and procedures.
10.	EDI allows for the reduction in personnel.

A Technological View of EDI

Technically, EDI is the business-to-business transfer of documents. It can also be viewed as the business-to-business transfer of data or information [16], [25]. Essentially, instead of transferring paper documents using the mail or other transportation services, EDI transfers the documents in an electronic form using telecommunication links. The traditional paper transfer for a purchase order is when the buyer's computer information system prints a paper order which is manually transferred to the seller. The seller then manually enters the buyer's order into the seller's computer information system. In the late 1960's as more firms began to use computer based information system, they began to realize much of the output of one computer is input to another computer [9], [10]. This along with the need to reduce costs lead firms to develop EDI. Implementing EDI can be done with very little integration into the existing information technology system in a company. Alternatively, EDI can be tightly integrated into an organization's information technology system. Generally, this is described as either integrated or non-integrated EDI. Non-integrated EDI is when a firm only uses EDI to transfer documents from or to another firm. In this situation, all of the existing paper processes in a firm are maintained but the transfer method is changed from a manual system such as the postal service to a telecommunication method. Typically, the telecommunication transfer is done through a third party vendor called a Value Added Network (VAN) supplier. The firm basically uses EDI to reduce document transfer time and by some estimates this is how over 70% of organizations implement EDI [17]. This is one end of the EDI implementation spectrum. At the other end is integrated EDI. Integrated EDI eliminates the flow of many types of paper documents both between firms and within a firm. As with non-integrated EDI, documents are transmitted electronically between firms. Unlike non-integrated EDI, the paper documents are never created, only electronic forms of the documents are created. For example, purchase orders are never printed but instead are created electronically and then transferred to the supplier, who receives them and processes the order without using paper documents. There is no manual keying of data by either the buyer or seller. Thus we can see that the level of integration is important in determining the financial costs and benefits of EDI to a firm.

EDI standards

EDI is an IOS by definition. It is a system of electronic communication of business documents between two organizations. There is an inherent difficulty in electronically linking two systems. Typically, internal organizational systems are designed around the needs of the organization; not its trading partners [21]. Since each business' system is designed separately, they are likely to be different and not directly compatible. Thus, there is a need for an IOS to enable the two dissimilar computer systems to communicate. This is the role of EDI standards.

There are several ways to classify EDI standards. One way is based on the information technology aspects of EDI. This would create a system with 2 types of standards - formatting and communication [10]. An alternative way to classify standards is based upon the type of organization responsible for initiating the standard. This classification systems leads to 3 types of standards - proprietary, industry, national and international [10].

Reasons to Adopt EDI

The literature shows that there are three major reasons that firms, both buyers and suppliers, adopt and implement EDI. First, firms may implement EDI for economic reasons [10], [27]. These firms recognize that EDI will reduce their costs and improve their cost structure. Second, there are strategic reasons to implement EDI [9], [24]. This includes improving customer service, locking in channel partners, and improving business performance. The third reason is simple coercion, which is non-voluntary, where firms are required by their customers or suppliers to implement EDI in order to continue relationships [22]. The first two reasons can be thought of as voluntary reasons to adopt EDI [10],[27]. Each of these three reasons is discussed below.

One of the initial reasons to implement EDI is to lower costs [2]. Reducing costs to stay competitive is very crucial for organizations that are in today's highly competitive markets [27]. EDI can reduce three primary costs: transaction, inventory, and error costs. Transaction costs include data entry, postage and mailing costs. Error costs include the direct cost of re-keying incorrect data and the indirect costs of supply chain disruption caused

by incorrect quantity, part number, delivery date, etc. Inventory costs arise from holding excess inventory, stockouts and backorders. Reducing these costs becomes important to firms that have high labor costs relative to competitors with lower labor costs. Without EDI, some firms would not be cost competitive.

There are at least 4 major ways that EDI can improve business performance and achieve strategic goals [24], [9], [10]. These are

- Improved customer service
- Information enhancement
- Global focus
- JIT tool.

A higher level of customer service is often considered a market advantage. As products have become more homogeneous, customer service is often used to differentiate one product or supplier from another. EDI, with its ability to quickly transmit information, can improve customer service by allowing customers to receive information in a more timely fashion. This is especially true for companies that operate across many time zones.

Information enhancement is another major way to improve business performance [10]. Data is transferred much faster in an EDI system than in a paper-based system. This enables firms to quickly determine changes in the marketplace and improves their ability to respond to the changes. EDI also makes it possible to transmit information quickly throughout an organization, which enables everyone to have up-to-date information for planning, and decision analysis.

More and more firms are operating in a global market. One of the difficulties of working with vendors and customers throughout the world is the difference in time zones. EDI allows firms to transact business regardless of the time and day of the week. Thus, EDI can enhance a firm's ability to operate in a global marketplace.

JIT has become a common basis for the operations of many firms. The fast and efficient communication of EDI is almost a necessity for successful implementation of JIT [3]. EDI fills the JIT requirements for fast and accurate transactions between trading partners. Its ability to provide rapid feedback on order status increases schedule stability [10]. Banerjee and Golhar [3] found that EDI related benefits are higher for JIT firms than for non-JIT firms. This conclusion is confirmed by Srinivasan, Kekre, and Mukhopadhyay [28] who report that performance improvements by JIT systems are enhanced through information technology like EDI. Thus it appears that EDI is almost a requirement for successful implementation of JIT.

One would assume that these economic and strategic benefits are the main reasons for adopting EDI. However, it appears that there has been little voluntary adoption of EDI to obtain these benefits. Instead, the main reason for adopting EDI is usually coercion, which is non-voluntary [8], [15], [27], [14]. Typically, large, powerful organizations (generally buyers) require their trading partners (usually sellers) to adopt and implement EDI or lose business. The result is that 90% to 95% of the firms implementing EDI are suppliers to large firms according to Horluck [14]. Crum, Premkumar, and Ramamurthy [8] reported similar findings in their study where 71 out of 80 (89%) respondents, indicated that "the customer initiated EDI." This is not to say that suppliers do not initiate EDI with their trading partners [10]. There are many cases where suppliers do initiate EDI, however it is more common for the buyer to initiate EDI.

Only a relatively small percentage of firms have implemented EDI despite the potential benefits of using it. Approximately 40,000 U.S. firms and 70,000 firms worldwide had adopted some form of EDI in 1995 [17]. This is well below the predictions of researchers. For example, Emmelhainz [10] reports predictions of 70% of US firms "making significant use of EDI" by 1993 with "over 400,000 organizations worldwide using EDI by 1995." EDI is now approaching its 30th birthday and yet it has been adopted and implemented by less than 5% of businesses in the US and less than 5% of firms worldwide with some reports indicating less than 1% of US businesses implementing EDI [26]. Businesses have adopted other information technology innovations like personal computers, e-mail and the World Wide Web much more readily than EDI.

It appears that firms do not obtain some of the benefits [15] or relative advantage of EDI [22]. For example, while reducing inventory is listed as one of the main advantages of using EDI [23], Pfeiffer [21] found that 60% of the firms implementing EDI do not realize changes in inventory after EDI is implemented. It is interesting that this 60% gap between perceived and achieved inventory benefits has not been well explained. Crum, Premkumar, and Ramamurthy [8] also report that firms are not reporting financial benefits from EDI.

The strategic reasons for adopting EDI have been extensively studied [9], [14], [19], [22], [27]. Coercion, while an important reason for adoption, has been extensively studied in the marketing channels literature and by others [22] will not be addressed here. There has however been little research into the economic benefits of EDI. In the next section we use the factor research approach to study the economic reasons for adopting EDI.

Economic Structure of EDI

We propose that one of the major underlying reasons for both the lower than expected EDI adoption rates and less than one-half of the firms reducing inventory is that the benefit models of EDI that are used do not include critical variables which impact potential benefits. A more complete model is offered next, which focuses on the level of integration, a buyer versus seller orientation, the type of inventory system, and the number of trading partners. However, this is generally not a factor that is included in research studies. Finally, the value of EDI is dependent upon the inventory system utilized by the firm.

Level of Integration

Firms can either integrate EDI into their existing information system or implement a non-integrated stand-alone system. The level of integration has a significant impact on the economics of implementing EDI. Bergeron and Raymond [6] found a positive relationship between integration and perceived benefits of EDI. Any firm utilizing EDI will experience a reduced transaction time. Transaction time is reduced due to the decreased time required to send the transaction when utilizing electronic means as opposed to traditional mail [11]. Thus a buyer firm could theoretically reduce its inventory level by 4 to 6 days of usage through the use of EDI. The supplier firm may not be able to do this and may in fact end up having to raise its inventory [23] which will be discussed later. In addition, the integrated firm will also have additional savings due to reduced keying expenses and lower error costs. The non-integrated firm must still re-key the transaction and will have errors associated with the keying. Finally, the integrated EDI firm will experience less internal delay in processing transactions since a transaction will be recorded as soon as the transaction arrives, instead of waiting to be recorded manually.

Alternatively, while the integrated firm should reap more benefits, it will also experience more costs. It is much more expensive both from an initial installation standpoint and from an ongoing support standpoint to integrate EDI with a firm's internal information system. The hardware and software costs associated with integrating EDI with an existing information system are far greater than a non-integrated solution [7]. Changes in the firm's information system must include the additional task of maintaining compatibility with the EDI system. In addition, integrated EDI, which draws information technology resources from other firm projects, takes considerably more time to implement than non-integrated EDI. Also, changes in the EDI system have the potential to impact the firm's information system.

Buyer versus Seller

Most cost models for EDI implicitly assume a single model will work for both the supplier and buyer firms. Basically, it is assumed that both the buyer and seller reap the same benefits by using EDI. Interestingly, research has pointed out differences between how buyers and sellers perceive the benefits of EDI although the reasons are not understood [23]. For example, Barua and Lee [5] reported that only 5% of 250 Ford suppliers could identify direct cost savings from using EDI. Additionally, the benefits of EDI depend upon the level of integration of EDI with an organization's existing information system.

For a large buyer with many EDI-capable suppliers, there are a large number of transactions and thus a large potential cost reduction. The buyer can adjust inventory and safety stock due to the reduced lead-time, lower transaction costs, and reduced variances in the lead-time. Each supplier which implements EDI saves the buyer money, thus there is a strong incentive for the buyer to get more suppliers to join the system.

A supplier can implement EDI on its own or because a customer requires it. The selling firm will experience different effects than the buyer when the buyer implements EDI. The seller will experience more frequent orders that will increase transaction costs [12]. Research indicates that sellers often experience an increase in inventory levels due to their partners implementing EDI [23]. The seller might also be forced to produce products more frequently. All of these effects will increase costs for the seller. Also the effect of the increased number of transactions will have a more negative impact on sellers with non-integrated EDI as compared to those with integrated EDI. Additionally, it is unlikely that the supplier will be able to use its EDI system with its own suppliers to obtain additional benefits. Most literature seems to indicate that EDI systems are not integrated throughout the supply chain, but instead exist only between a large customer and its suppliers in a single layer hub and spoke system [7]. Generally, suppliers do not have EDI links with their own suppliers. Consequently, the intermediate supplier does not have the ability to adjust inventory to reduce costs as their customer can.

The supplier that initiates an EDI system does not have the same potential for savings as the buyer that initiates an EDI system. This may explain why literature reports most EDI systems as being buyer based not

supplier based [5], [8], [10]. The supplier does not have the ability to significantly adjust its inventory levels due to EDI.

Inventory System

Implementing EDI has the potential to reduce a firm's inventory costs [10]. The reduction may arise for two reasons. First, EDI reduces transaction times and with it order cycle times. Second, EDI reduces the variance in order cycle times [10]. Depending upon the type of inventory system a firm uses these two changes can reduce total inventory costs. In all cases, reduced variances in the order cycle time should reduce safety stock inventory in all inventory systems. However, the effects of lower transaction costs and lead times will have differential effects based on the firms inventory system.

There are two basic types of inventory systems - fixed interval/variable quantity and variable interval/fixed quantity. Additional information on inventory systems can be found in various sources (e.g., [13], [29]). Classical MRP is an example of a fixed interval/variable quantity system; orders are placed weekly. EOQ and Kanban are examples of variable interval/fixed quantity systems in which the same predetermined quantity is ordered when a reorder point is reached. The effects of implementing EDI on each of these two types of inventory systems will now be discussed.

Fixed Interval/Variable Quantity Inventory System

These types of systems will see a minimal impact due to adopting EDI. As stated above, the safety stock inventory will be reduced due to decreased order cycle time variance. However, there will be no effects on the main inventory level. This is due to the MRP schedule that determines inventory level. The inventory level for the MRP schedule is not responsive to reduced order transaction times or costs and thus it will remain the same. A reduction in the order transaction time could change the order release date, but it would not change the time between when the order is received and utilized. This is true for both supplier-initiated and buyer-initiated systems.

Variable Interval/Fixed Quantity Inventory Systems

These types of inventory systems will have substantial inventory changes due to implementing EDI. In EOQ systems buyers will have significantly lower order transaction costs. This will result in smaller, more frequent orders which matches research findings of Banerjee and Golhar [2]. The smaller orders result in reduced average inventory levels and lower costs for the buyer who initiates EDI. Also, the reduced lead-time lowers the reorder point. Finally, the reduced lead-time changes the distribution of the demand during the lead-time and the distribution of the lead-time itself. It is expected that for both distributions, that the means will be smaller. Additionally, it also appears that variances will be smaller and thus there will be a smaller safety stock.

If a buyer is utilizing a kanban system, implementing EDI will have a somewhat different effect. The buyer will have the same safety stock effects as in the EOQ system. In addition, the buyer will reduce the number of supplier kanbans due to the decreased lead-time. This will not have a direct effect on the buyer but instead the supplier, which typically experiences the inventory costs of supplier kanbans during the lead-time period, will see a reduction in inventory [18].

Number of Trading Partners

Initiating firms appear to very aggressive in signing on EDI trading partners. It appears that the reason for this is economic. The EDI system is expensive to implement and does not experience significant cost increases as the number of trading partners using EDI increases. Thus it appears likely that the benefits of EDI to the initiating party increase as the number of trading partners using EDI increases. This network externality would encourage firms to increase the number of their EDI trading partners.

Economic Model of EDI

An economic cost model is needed to study the impact of EDI on a company. Based on the above findings, one single cost model will not explain all EDI implementations. Several different EDI cost models based on the four factors presented above, level of integration, existing inventory system, initiating party, and number of trading partners, are needed. The following generalized model is proposed based on the buyer's perspective. A specific model would then have to be developed for each of the combinations of the factors. Figure 1 shows the relationship graphically.

EB=f(I, V, T,P)

where:

EB = EDI Benefit
I = Level of integration
V = Existing inventory system
T = Number of trading partners
P = Initiating partner

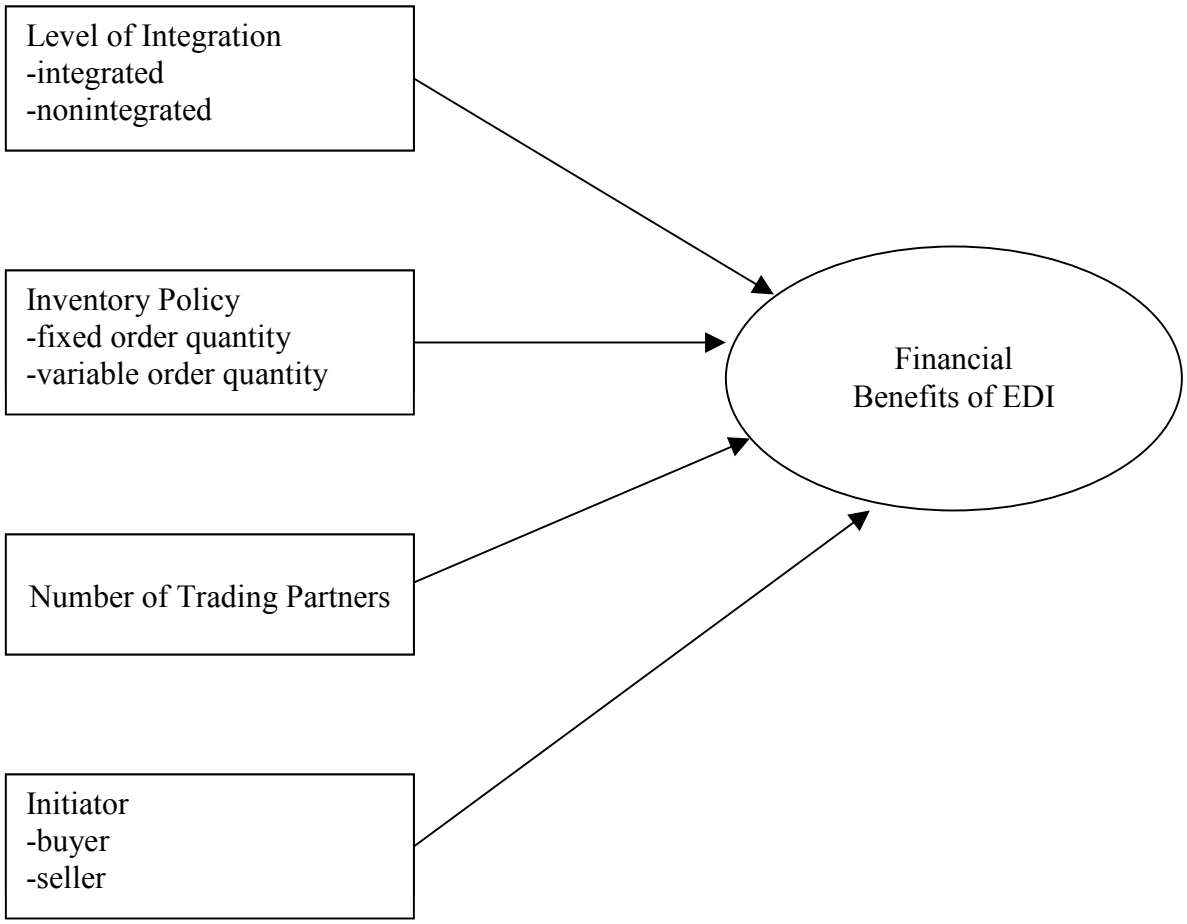

Figure 1. Graphical Representation of EDI Benefit Model

Typically, one is comparing EDI systems to paper based systems. In order to do this comparison the model only needs to include the factors that are different between the EDI and paper systems. Thus, the models should use just the total relevant costs in a manner similar to Banerjee and Banerjee [1].

EDI systems are also usually developed as a long-term business system. This is especially true for integrated systems, which have high setup costs and potentially major impacts on an organization's operations [12], [5]. In order to determine if EDI is cost effective, based on the rational view of a firm [30], a net present value comparison of the EDI system to a paper based system should be done. To do this, the quantifiable costs and benefits of the EDI system need to be determined. In addition, firms would need to quantify their intangible benefits. From this, a yearly cost function can be developed and then a net present value function can be developed. A comparison of the net present value of the EDI and paper systems can then be made. Additionally, given the rapid changes in information technology it is suggested that a maximum of a three-year time horizon be used for the NPV calculations.

Directions for Future Research

This paper has suggested multiple areas that should be researched. Specifically it is suggested that there is a need for additional research regarding the economics of EDI, the value of formatting standards, integration issues, and the effects of EDI on order cycle time variances. These are discussed further now.

Economic Model

This paper argues that there is not one single economic cost function for EDI but instead multiple models are needed. The factors that should be included in the models are level of integration, initiator of EDI system, inventory system. Further research is needed to develop these models and study their applicability.

Integrated versus non-integrated EDI

Very little research has been done regarding the level of EDI integration. Although several sources suggest that firms often adopt a non-integrated form of EDI, it is not known how this changes over time and with firm size. It is significantly less expensive to implement non-integrated EDI however it appears that there are significantly more benefits to integrating EDI with a firms information system. It would seem logical that as non-integrated EDI firms become comfortable with EDI, that they would explore the option of integrating EDI.

Also, while it is suggested here that the initiating firm is more likely to have integrated EDI and the respondent firms are more likely to have non-integrated EDI, this has not been tested empirically. Also, it is likely that there is a firm size effect on level of integration that should be tested.

EDI Effects on the Variance of Order Cycle Time

Research indicates that there will be reductions in order cycle time variance when EDI is implemented. The actual change in variation is not known. As order cycle time variance decreases, safety stock will decrease as well. However, the magnitude of the changes in safety stock is unknown. The exact relationship between implementing EDI, the change in order cycle time variance, and level of safety stock are unknown and should be researched.

Conclusions

EDI has existed for 30 years yet it has not been widely adopted. There are various reasons for the slow adoption rate for EDI when compared to other information technology innovations including unrealistic financial expectations and difficulty in implementation. The basic outline for an EDI benefit model (Figure 1) proposed here provides an improvement to existing economic models. This model provides a basis for both a better understanding of the slow adoption rate of EDI and how changes in technology costs should affect future EDI adoption.

Several companies now market EDI packages that utilize the Internet for the telecommunication link. As more and more firms utilize the Internet instead of VANs, the costs for EDI should decrease. However, the effectiveness of EDI over the Internet has not been well researched. Finally, by comparing the adoption rate of EDI to other information technologies, one can better understand the implementation process of EDI and where it will be in the future.

As with all research there are limitations to this paper. First, the paper generally assumes that organizations act logically. That is, they make decisions in order to achieve organizational goals. While this is a reasonable assumption it is also true that firms often make decisions that are not in the best interests of the organization as a whole. Individuals and groups make decisions for firms that may benefit those making the decision and not the firm. These situations are not addressed in this paper.

Second, in this paper EDI is primarily viewed as a technology not as a business process. If one views EDI as a business process, it is likely that additional factors would have to be included in an economic analysis. Finally, research results indicate that EDI is often only used for less than half the transactions for many firms [12], [8]. Thus any economic analysis done must realize that at least initially both an EDI system and a paper-based system will be required. This has the potential to reduce the economic benefits of using EDI.

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