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Introduction

Based on the theory of transaction cost economics (Coase, 1937), the traditional purchasing literature has identified two types of buyer-supplier interaction: (1) the market, with high flexibility but low integration between buyers and suppliers; and (2) the hierarchy, which requires long term commitment and trust to invest in relationship specific assets (Williamson, 1975, 1985). New information and communication technologies, such as electronic data interchange (EDI), are becoming less relationship specific, allowing a closer inter-organizational integration without the risk involved in large expenditures in relationship specific assets, and simultaneously overcoming the drawbacks of markets and hierarchies (Clemons & Row, 1992; Clemons et al., 1993; Malone et al., 1987, 1989; Prosser & Nickl, 1997; Holland & Lockett, 1997).

For the purposes of this study, EDI is defined as any inter-organizational exchange of data, in electronic form and structured in such way that it can be communicated directly from computer system to computer system. This definition is consistent with the definition given by the British Government (Department of Trade and Industry, 1989) and with definitions generally used in the academic EDI literature (e.g. Hansen & Hill, 1989; Banerjee & Sriram, 1995; Ferguson et al., 1990).

The current explosion in internet traffic and their ease of access and low cost has made electronic communications affordable for even small suppliers (DeCovny, 1998; Deloitte Consulting, 1998). For all these reasons, the use of EDI is gaining more general acceptance and EDI related issues are becoming increasingly important to researchers (Yrle, Hartman, & Payne, 1999).

Purpose and relevance of the study

The purpose of this study is to develop and empirically test a model that explains the determinants of the adoption of EDI between manufacturers and their suppliers in international supply chains. The model is tested in in-bond industrial plants in the Mexican state of Tamaulipas. In-bond plants in Mexico are generally known as maquiladoras or maquilas, and these terms will be used interchangeably in this report.

This study specifically identifies the factors leading to EDI adoption in maquila plants. In spite of the importance of local manager's perceptions regarding the economic efficiency of EDI, supply chain institutions such as customers, suppliers, or industry regulatory organizations play today an important role in technology adoption decisions. For example, in previous studies of EDI use in the transportation industry, it was found that the decision to adopt EDI is more influenced by customer service considerations than by economic efficiency (Crum, Johnson & Allen, 1998; Johnson, Allen & Crum, 1992). Attempting to clarify this issue, this study compares economic efficiency, operationalized as perceived benefits of EDI use, and institutional factors, operationalized as external pressure exerted on the plant to adopt EDI, as the key determinants of EDI adoption. The issue of the decentralization of the purchasing function between corporate headquarters and plant is of particular interest here because maquiladoras are typically dependent and controlled by a parent firm outside Mexico (Grunwald & Flamm, 1985).

Stank, Emmelhainz, & Daugherty (1996) have shown that exchanging information with suppliers is positively related to supplier performance, and concluded that firms should include EDI implementation support in their supplier development efforts. Although the literature suggests that manufacturers should be involved in

supplier development activities, there is evidence to suggest that the actual practice of supplier development in information technologies is very limited. For example, a survey of suppliers in the automotive industry showed that most buyer-supplier relationships involve low levels of commitment and information exchange, although those levels were gradually increasing (Helper, 1991). In addition, a study by Walton (1996) suggests that operational information exchanges, particularly in the form of EDI, account for a significant amount of variance associated with supply chain partnership satisfaction and that managers are not satisfied with current information exchanges with their supply chain partners.

This study addresses these important issues by analyzing the adoption of EDI between buyers and suppliers, and provides normative insight for the management of firms and supply chains. Since the ability to exchange information with supply chain partners is increasingly becoming a requirement to becoming a member of the supply chain (Choi & Hartley, 1996), the use of information technologies can stimulate small business growth which is an important factor of regional development (La Rovere, 1998; Thwaites & Oakey, 1985). Therefore, to the extent that firms are using or planning to use the ability to exchange electronic information as a supplier selection factor, this study also has important implications for policy making and economic development.

The main benefits of EDI reported in the literature are cost reduction, increased speed, and reduction of errors. Paper based systems are labor intensive (Ferguson et al., 1990), and automating processes will reduce paperwork, paper handling and paper cost (Holland & Lockett, 1997). Firms that encourage their vendors to use EDI are better able to capitalize on EDI advantages such as reduced monitoring of suppliers, automatic

reordering, and simplified order approval processes (Banerjee & Sriram, 1995). In addition, the use of EDI improves customer service and responsiveness to special customer requests (Rogers et al., 1992; Bowersox & Daugherty, 1995). EDI has been reported to reduce the inventory level, improve cash flow, and streamline a company's operations (Dearing, 1990). In the only study to date of EDI in the maquiladora industry, Stank and Lackey (1997) found that plants that are willing and able to exchange data with their supply chain partners and invest on EDI related technologies, improve their logistical performance.

In spite of the numerous reports showing the positive impact of EDI on profitability and operational performance (Banerjee & Sriram, 1995; Bowersox & Daugherty, 1995; Rogers et al., 1992), the use of this technology by organizations has been traditionally low (Fergusonet al., 1990; Hendon, Nath, & Hendon, 1998; Pfeiffer, 1992; Gottardi & Bolisani, 1996; Richeson et al., 1995), although it has been reported that EDI use is gradually increasing (e.g. Crum et al., 1998).

Determinants of EDI adoption

Recent studies (Adams, Nelson, & Todd, 1992; Davis, 1989; Mathieson, 1991; Moore & Benbasat, 1991; Taylor & Todd, 1995) have analyzed the determinants of information technology adoption in organizations. Factors that influence the decision to adopt EDI include the expected efficiency and customer service gains (Rogers et al., 1992; Bowersox & Daugherty, 1995; Jimenez-Martinez & Polo-Redondo, 1998), and anticipated system compatibility (O'Callaghan et al., 1992). Chen and Williams (1998) related the use of EDI in small businesses to the power of customers, the organizational culture, and the personal opinion of the managers.

EDI in international transactions

Longer supply chains increase the uncertainty, delay technical support, require longer demand forecasting periods, and higher levels of inventory (Levy, 1995, 1997). Frequent internal process disruptions, high processing cost of international trade paperwork, the ability of EDI to overcome traditional cultural, language, and bureaucratic barriers to international trade, and the need to improve productivity derived from international competition, make EDI use critical in international transactions (Levy, 1995). In addition, the high cost of international travel limits the frequency of personal communication (Lawrence & Lewis, 1993). Such factors provide an incentive for firms to rely on electronic communications for their information flows. At the same time, enhancing the flow of information and materials is costly and difficult to achieve, particularly in international supply chains.

A single business transaction can give rise to the exchange of between five and twelve documents in domestic transactions, and up to thirty documents in international transactions (Emmelhainz, 1990). The use of EDI in international transactions results in expedited cargo releases, entry summaries, payment through automated clearinghouses, shipper's export declarations, and other international transportation procedures (Murphy & Daley, 1996). EDI will standardize, simplify and increase the speed of information flows in international transactions (Janssens & Cuyvers, 1991). In spite of the abundant theoretical and empirical support of the benefits of EDI use in international transactions, Ferguson et al. (1990), found limited use of EDI in firms engaged in international transactions.

In addition to longer and more variable transportation times, reliance on international suppliers makes it more difficult to involve suppliers in solving quality problems and improving designs. The intense communication between manufacturers in Mexico and their international suppliers is extremely difficult because of language differences and the low reliability of traditional communication services such as telephone and mail.

The Mexican maquiladora industry

The increasing level of globalization and international competitiveness, particularly from Asian countries, is forcing manufacturers to transfer critical processes into low cost countries such as Mexico. The Mexican maquiladora industry was created in 1965 through an agreement between the United States and Mexico, the Border Industrialization Program (e.g. Grunwald & Flamm, 1985). The purpose of this program was to bring down unemployment in Northern Mexico by encouraging foreign firms to establish production sharing facilities, which can take advantage of the abundant labor force in the area. Through this program, components can be imported into Mexico with no tariffs, to be assembled in a maquiladora plant, and re-exported. Today, the maquiladora industry has expanded into the interior of Mexico, employs more that 1,200,000 people in more than 3,500 plants (INEGI, 2000), is the third source of foreign exchange only after oil and tourism, and has become a factor of economic stability for Mexico and border areas in the United States (Botzman, 1999).

Although many suppliers are gradually moving closer to the location of the maquiladoras, the vast majority are still located in remote areas, particularly in the Midwest U.S. states. Such geographical distance can be problematic since suppliers have

to deal directly with maquiladora plants for purchasing, logistics, design and quality issues (Dowlatshahi, 1998). As Table 1 shows, about 97 percent of the purchases in the maquila industry are imported. The proportion of imported purchases is even higher in border states such as Tamaulipas (INEGI, 2000).

Table 1

Distribution of Maquiladora Purchases in 1999

Total for Mexico:			
	Millions of pesos	Millions of US dollars	Proportion of total
Imported	426,912	44,563	97.19%
National	12,337	1,288	2.81%
Total	**439,249**	**45,851**	**100.00%**
State of Tamaulipas:			
	Millions of pesos	Millions of US dollars	Proportion of total
Imported	82,506	8,612	98.87%
National	939	98	1.13%
Total	**83,445**	**8,710**	**100.00%**

Source: Instituto Nacional de Estadística, Geografía e Informática (INEGI)

Maquiladora operations have become more technologically sophisticated in later years. Once dominated by simple assembly operations, today's maquilas use sophisticated equipment to perform capital intensive, complex manufacturing operations that are key processes in the supply chain. The growth of high technology industries such as computers and medical equipment has contributed to the increase in the technological level in maquiladora plants. Maquilas have also become involved in the design process, which requires close cooperation with suppliers and customers (Fawcett, Stanley, & Smith, 1997). Since nearly all maquiladora purchases are made from suppliers in other countries, the Mexican maquiladora industry is an optimal location to analyze information flows in international supply chains.

In spite of increasing technological sophistication and strategic relevance of maquiladora operations, maquiladora managers have taken a reactive stance in strategic logistic decisions (Fawcett & Smith, 1995). Since using EDI is a critical determinant of logistical performance (Stank & Lackey, 1997), a better understanding of the determinants of EDI adoption in maquiladora plants will provide crucial guidance for maquiladora firms and supply chains.

Research Hypotheses

Based on an extensive literature review, a model of EDI adoption decision process is developed in this section. According to this model, the main determinants of EDI adoption are efficiency factors such as perceived benefits and compatibility of the EDI system, as well as institutional factors such as external pressure to adopt the technology. These factors are hypothesized to depend, in turn, on other structural factors such as the size of the plant. Economies of scale justify a direct relationship between plant size and EDI use. The level of centralization of the purchasing function is also hypothesized to have an impact on EDI use. The following discussion explains in more detail these relationships and develops formal hypotheses.

The adoption of supply chain improvements such as EDI is very often triggered by macro-social factors such as trading partner pressures, especially from customers (Jones & Beatty, 1998; Chen & Williams, 1998; Hendon et al., 1998; Marcussen, 1996; Hart & Saunders, 1997), and, less frequently, from suppliers (Chen & Williams, 1998; Sriram & Banerjee, 1994). Buyer power is the influence of buyers to impose trading terms or interorganizational technologies on their suppliers (Holland et al., 1992; Hart &

Saunders, 1997). It has been shown that buyers use their buyer power to pressure their suppliers to implement EDI (Tuunainen, 1998).

When EDI is implemented on a supply chain basis, a dominating institution typically determines the standards, organizes the communication protocols, and establishes norms requiring all the other supply chain members to implement EDI. This leading institution can be a member of the supply chain, a consortium formed by industry members, or an institution chartered by the industry leaders to set standards in order to organize the supply chain. Industry institutions can therefore influence the EDI adoption decision of individual firms with the objective of improving the performance of the supply chain (Tuunainen, 1998).

H_1: External pressure will have a positive effect on the adoption of EDI in maquila plants.

Perceived benefits, also referred to as relative advantage, need pull, internal need, or efficiency advantage (e.g. Premkumar & Ramamurthy, 1995; Zmud, 1984), has been cited in the literature as a major factor influencing the decision to adopt EDI. In spite of the evidence of improved supplier performance, it has been shown that suppliers do not perceive they benefit from EDI as much as they could, and that the benefits of EDI are not well distributed between buyers and suppliers (Marcussen, 1996; Tuunainen, 1998). In their study of EDI use in the transportation industry, Crum et al. (1998) report that the largest perceived benefit of EDI is in the area of customer service as opposed to efficiency gains, and carriers report that their customers are more satisfied with the EDI system than they are. According to this view, purchasers exert power on their suppliers to force them to implement EDI, and benefit financially from the improved purchasing

decisions while suppliers do not recognize enough financial gains derived from the use of EDI technology.

Managerial understanding and attitude towards a new information technology are associated with the likelihood of its adoption (Lal, 1999). Given the efficiency gains derived from EDI analyzed in detail in the literature review, it is hypothesized that intra-organizational economic efficiency factors such as the manager's perception of EDI benefits are a factor contributing to EDI adoption (e.g. Iacovou et al, 1995; Jones & Beatty, 1998; O'Callaghan et al., 1992). Managers who understand the benefits of EDI adoption are more likely to allocate the managerial, financial, and technological resources needed for EDI adoption (Premkumar & Ramamurthy, 1995). Therefore,

H_2: Perceived EDI benefits will have a positive effect on the adoption of EDI in maquila plants.

Compatibility is the level of consistency of a technology with organizational systems, procedures, and practices (O'Callaghan et al., 1992; Premkumar & Ramamurthy, 1995; Iacovou et al., 1995). As potential users of a technology perceive that the adoption will cause fewer disruptions in processes and will require lower investments and modifications to current systems and procedures, they will be more likely to implement it (Rogers, 1983).

H_3: Perceived EDI compatibility will have a positive effect on the adoption of EDI in maquila plants.

In general, size is related to the availability of both human and physical resources to facilitate the adoption of technology. Size is a determinant factor in the adoption of all types of technology (Germain et al., 1994; Grover & Goslar, 1993; Lal, 1999; Fariselli et

al., 1999; Damanpour, 1987). With particular relevance to this study and using production function estimates from Mexican data at the plant level, Grether (1999) found that plant size is a significant determinant of technological diffusion.

There is substantial evidence of the relationship between firm size and EDI adoption (Daugherty et al., 1995; Murphy et al., 1998; Murphy & Daley, 1996; Williams et al., 1998; Barua & Lee, 1997; McGowan, & Madey, 1998; Premkumar et al., 1997; Fariselli et al., 1999; Tuunainen, 1998; Chen & Williams, 1998; Germain & Droge, 1995). Economies of scale allow larger organizations to make a higher return on their technology implementation investments (Clarke et al., 1992), while EDI becomes a "strategic necessity" to smaller suppliers competing against larger, technologically sophisticated suppliers (Barua & Lee, 1997). No matter what the efficiency advantage perceived by the potential EDI adopters, fixed investment on EDI capability will be most profitable to larger firms with more resources and potential use for the system, and to firms with more potential partners to communicate with (Tuunainen, 1998). Although it has been reported that lack of flexibility could reduce the number of innovations in larger firms (Grover & Goslar, 1993), factors such as the availability of slack resources and economies of scale support the higher EDI adoption levels in larger plants.

H_4: Plant size will have a positive effect on the adoption of EDI in maquila plants.

A large body of literature has analyzed the relationship between technology adoption and organizational structure, obtaining conflicting results (e.gMiller et al., 1991; Grover & Goslar, 1993; Gatignon & Robertson, 1986). Decentralization is an empowerment of particular business units at lower levels in an organization, enabling

them to make decisions. Based on the idea that centralized firms are better suited to adopt innovations that require organizational standardization (Gatignon & Robertson, 1986), Williams et al. (1998) hypothesized a positive relationship between centralized organization structure and EDI use, but found no empirical support. Other research, however, has shown that the decentralization of innovation adoption decisions is positively related to the likelihood of adoption. For example, Germain (1996) found that the decentralization of logistic process innovation adoption decisions is a good predictor of low cost incremental innovation, but not of radical innovation. The positive relationship between decentralization and innovation adoption is based on the fact that centralized firms reduce autonomy in the functional areas of application of the technology, and decision makers in headquarters are withdrawn from these functional areas, and have a bounded perspective. Employees in decentralized firms are empowered to suggest and implement technological innovations. Decentralization provides managers the freedom to be innovative. If the innovation under consideration involves a very large, complex, or expensive project, however, the resources needed might not be available at the local level, and plant employees might be unwilling to take the risks and personal responsibility associated with the innovation adoption decision.

Given the strong control of corporate headquarters over maquiladora plants, it seems reasonable to hypothesize that plants with more responsibility over the purchasing function will use more EDI than plants with no control of the purchasing function.

H_5: The level of decentralization of the purchasing function will have a positive effect on the adoption of EDI in maquila plants.

Survey Development

The construction of sound measuring devices is crucial in any study and particularly when using survey instrument to measure abstract constructs. External pressure to implement EDI was measured through four likert scale questionnaire items, reflecting the level of agreement of the respondent with four sentences stating that the plant is required to implement EDI by customers, suppliers, headquarter policies, and the industry. To measure EDI use, dichotomous questions were used regarding EDI use with suppliers of each plant. As a measure of the perceived benefits and compatibility of EDI, the 16 item scale validated by Jones and Beatty (1998) is used. This scale assures content validity for both pre- and post-adoption perceptions, because the items have been generated from independent research studies on both groups.

The number of employees in the plant was used as a proxy for plant size. This measure was taken because it is considered public information, and has been previously published in other sources and directories. This suggests that few managers would object to respond to this question. Firm size was transformed into natural logarithms to improve linearity.

In our measurement of decentralization, we are specifically interested in the level of autonomy of the plant versus the corporate headquarters for purchasing tasks. The list of basic purchasing functions provided by Heinritz et al. (1986) was considered appropriate to develop an instrument to measure the level of the plant-headquarter decentralization of the purchasing function. Accordingly, we prompt for the level of responsibility assigned to the plant for main purchasing tasks of selecting suppliers, generating purchasing orders, expediting outstanding orders, receiving and inspecting

materials from the suppliers, checking the supplier invoices, sending requests for quotations, and inspecting for quality.

Out of the 453 plants included in the master list, it was determined that 38 plants did not physically exist and, thus, were not surveyed. Questionnaires were sent to the remaining 415 plants. Out of the 187 questionnaires received, 25 did not have enough information to be used. In total, 162 usable questionnaires were received, a 39% rate of response, which is extremely high in the context of the maquiladora industry.

Statistical tests were performed to assure the randomness of missing data, absence of nonresponse bias, and outliers. Cronbach's alpha statistics were computed to assess the internal consistency reliabilities of the multi-item measures. All multi-item measures meet the minimum alpha benchmark of 0.70 established by Nunnally (1978), suggesting a strong inter-item covariance. The unidimensionality of the measures was established by performing a principal component factor analysis with varimax rotation on all questionnaire items of multivariate measures. One item did not load clearly on any factor and was eliminated from the analysis. All factor loadings meet the significance standard of 0.4 suggested by Ford, MacCallum and Tait (1986).

Data Analysis

In order to test our hypotheses, a binary logistic regression was estimated with the dichotomous EDI use as dependent variable, and external pressure (H1), perceived benefits (H2), perceived compatibility (H3), plant size (H4), and decentralization (H5), as independent variables.

The results (Table 2) show that plant size, external requirements, perceived benefits, and perceived compatibility have a statistically significant effect on EDI use, and all the coefficients have the expected signs. The coefficient for decentralization, however, is very small and statistically insignificant. There is, therefore, support for H1, H2, H3, and H4, but not for H5. Larger beta coefficients are associated with larger contributions to the probability that a plant will use EDI. Plant size has the largest beta coefficient, followed by perceived benefits, perceived compatibility and external requirements. These variables are, therefore, the best predictors of EDI use in maquiladora plants.

Table 2

Logistic Regression Coefficients

	B	S.E.	Wald	df	Sig.	Exp(B)
LOGSIZE	1.333*	0.592	5.061	1	0.024	3.791
DECEN	0.049	0.179	0.074	1	0.786	0.952
EXREQ	0.849**	0.280	9.163	1	0.002	2.337
PERBENE	1.024*	0.449	5.206	1	0.023	2.784
PERCOMP	0.856**	0.327	6.850	1	0.009	0.425
Constant	-11.434	3.546	10.397	1	0.001	0.000

Overall model chi-square: 59.63 with 5 degrees of freedom.
* $p<.05$
** $p<.01$

A classification table for the logistic regression is presented in Table 3. The model was able to predict correctly 89.2 percent of the cases, versus a proportional chance criterion of 67.01%, which provides a highly significant classification accuracy ($p<.01$).

Table 3

Logistic Regression Classification Table

	Predicted			
Observed	Non-EDI	EDI	Total	Percentage Correct
Non-EDI	91	4	95	95.8
EDI	9	16	25	64.0
Total			120	89.2

Proportional chance criterion: 67.01%
Classification accuracy t=10.70, significant p<0.01

Findings and Conclusions

The results of this study show the importance of the link between external requirements and EDI adoption. Interorganizational ties such as those of maquiladora firms with their customers and suppliers serve both as a vehicle for diffusion of technology, and as a channel for institutional pressure and conformance monitoring. The diffusion of technology and the pressure to adopt it, therefore, is transmitted from customers to maquiladora firms, and, subsequently, to their suppliers. Exerting pressure on business partners will lead to faster adoption of interorganizational information technologies, and to the improvement of logistic performance. The role of inter-firm relationships is especially relevant in the case of interorganizational communication technologies, where the adoption of a common or compatible communication standard is a technical necessity. The pressure to adopt should be accompanied by training and support, making sure that the implementation does not just attempt to conform to the requirement, but it also maximizes efficiency for both buyer and supplier, and along the supply chain. Industry organizations can contribute to this process by taking advantage of economies of scale in the provision of support and training, and by providing standards

and implementation guidelines that make EDI systems less relationship specific, encouraging the creation of new interorganizational information links.

This study also found that perceived efficiency advantage is a strong predictor of EDI adoption. The adoption of EDI is, therefore, subject to a managerial understanding of the economic gains derived from the use of this technology. Perception of benefits of a technology can be gained through formal training or through informal processes such as social or vicarious learning (Rogers, 1983). Business partners can, therefore, have an impact on perceived benefits of EDI and their successful experiences can lead to imitation by other plants.

From a dynamic perspective, institutional factors can be expected to have a larger impact on the future implementation of EDI. Most empirical studies on adoption of technological and administrative innovations show that early adopters are more likely to respond to technical or economic efficiency arguments, while late adopters are motivated by the need to conform to network requirements. Accordingly, maquiladoras perceiving clear opportunities to improve performance with EDI systems would be the first to adopt, as is found in this study, but institutional factors will be the critical determinants of later adoption. Supply chain leaders and organizations, as well as other governmental and industry related institutions will play a critical role on future development of EDI in the maquiladora industry.

Perceived compatibility is also a strong predictor of EDI adoption. The perceptions that EDI implementation will be costly, will require the modification of plant processes, and will be difficult to learn affect the decision to adopt EDI. The availability of flexible software that can adapt itself to existing organizational processes, and

communication standards widely used in the industry, for example, will allow a faster implementation of the EDI system, at a lower cost and with lower training requirements. In order to reduce the level of incompatibility with present systems and procedures, supply chain partners must cooperate closely when planning the implementation of a new EDI link. The implementation plan must consider issues such as technical compatibility of hardware and software, consistency with current procedures of both organizations, support and maintenance costs, and the loss of time and productivity during the implementation and adaptation periods. Flexibility must be exercised on both sides to guarantee a smooth and mutually beneficial transition to the new system.

The ability and willingness to adopt new technologies in a plant is related to technology specific skills and training, as well as the cost/benefit relationship. Larger plants have the resources to train and hire more specialized personnel who possess the necessary skills to implement new technologies, and have a larger transaction volume, which will increase the cost efficiency of the implementation. Larger investments can be justified when EDI use with multiple partners generates a large volume of electronic transactions. According to this logic and hypothesis H4 tested in this study, plant size is a strong predictor of EDI adoption.

The level of decentralization of the purchasing function does not have a significant impact on adoption of EDI between maquilas and their suppliers. This finding suggests that opposite mechanisms can be in conflict in the relationship between decentralization and technology adoption. While decentralization provides the flexibility and autonomy for individual plants to acquire the resources necessary to adopt information links with suppliers, centralization can also facilitate the adoption of

common standards and provide the managerial support needed to implement the new technology. The opposing impacts of these mechanisms can explain the lack of significant results.

Factors such as pressure from customers, generalized use of EDI in the industry, the level of managerial training, and the size and technological sophistication of the plant affect the general attitude toward EDI. In order to take advantage of the efficiency gains associated with the use of EDI with suppliers, firms should include supplier EDI training and support among their supplier development efforts (Stank et al., 1996).

The case findings of this study suggest that the success of an EDI implementation might be linked to the factors that led the plant to adopt the technology. If the plant belongs to an initiator firm, the technology is transferred from the headquarter to the plant, and the plant will pressure its suppliers to adopt EDI. When the initiator firm is the customer, the customer will pressure the plant to adopt EDI to communicate with it, but not with other customers or suppliers of the plant. If there is a well defined communications strategy at the supply chain level, however, the technology transfer takes place at multiple levels of the supply chain, and under a single set of standards, which facilitates the expansion of EDI links with other supply chain partners without the need for additional investments in EDI software or programming. In addition, when EDI is initiated as a supply chain strategy, it is perceived by followers as a long-term policy, and they tend to invest in an integrated EDI system that automatically shares information with the internal system, rather than running an EDI application in a stand-alone PC.

Understanding the process of information technology adoption is crucial for firms and supply chains to attain higher levels of adoption that allow them to benefit fully from

information technology. The findings of this study are useful for managers as they plan their buyer-supplier communication policies, and for economic development agencies in the US-Mexico border area as they attempt to develop a local supplier base for the maquiladora industry.

Institutions play a key role in the process of technology transfer and adoption. The role of institutions is particularly critical in the transfer of information technology innovations to less developed countries (Montealegre, 1999). The findings of this study support the notion that institutions can stimulate the adoption of information technologies by establishing diffusion and training programs directed at plant management and their existing or potential suppliers. Institutions can help by providing training and awareness programs to both maquiladora managers and their suppliers. The availability of technical skills, together with an awareness of the importance of business-to-business communications, are critical factors for the development of successful suppliers for the maquiladora industry. The coordinated actions of economic development institutions, universities and maquiladora firms can lead to an efficient integration between maquiladora buyers and their suppliers. Examples of specific institutional actions include the promotion of applied research, education, training of specific target groups, promotional and awareness campaigns, establishment of technology standards, or the provision of shared infrastructure. The establishment of supplier networks can allow maquiladoras to share infrastructure and training costs and make the implementation of EDI more cost effective for smaller suppliers. Interestingly, a public policy directed to creating supplier networks to implement EDI will be reinforced by the use of the communication technology itself, since it will improve the communication among

suppliers as well as between suppliers and manufacturers. The institutional intervention can affect the perceived benefits of technology adoption, making maquiladora managers more proactive in their adoption efforts. By bringing together corporate buyers and local suppliers, institutions can stimulate the process of technological transfer beyond its historically low levels in the Mexican context (Grether, 1999).

Local supplier development and training in telecommunication readiness, as well as physical telecommunication infrastructure, are necessary factors for regional economic development. The cooperation of maquiladora firms with government institutions and universities is critical to achieve these goals and increase the efficiency and competitiveness of the maquiladora industry.

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