The Advantages of Electronic Data Interchange

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Abstract

The purpose of this research was to identify success factors of EDI implementation and the benefits organizations could obtain by using this technology. The success factors found empirically in a field study of 140 Canadian enterprises are the organizational support, the implementation process, the control procedures and the level of EDI integration in the firm. The level of success also depends upon the level of imposition of EDI by partners. The study found evidence that, in order of importance, the benefits of EDI implementation are improvements in terms of information quality, transaction speed, administrative costs, strategic advantage and operations management.

ACM Categories: H.4, K.4, K.6

Keywords: electronic data interchange, advantages, strategic information systems, inter-organizational information systems, organizational context, integration, imposition

INTRODUCTION

Electronic data interchange (EDI) is an application of information technology that allows business partners to send and receive commercial documents (e.g., invoices, bills) electronically from computer to computer instead of writing and mailing them (Hansen and Hill, 1989). It is among the key technologies of the nineties and might, according to Russel and Vitale (1988), bring a competitive edge to organizations as well as a reduction in costs and a strengthening of commercial links with customers, suppliers and other business partners.

EDI is growing rapidly and shows a promising future (Dillon, 1989; Straub and Wetherbe, 1989). It is forecast that the number of organizations using this technology will double every two years in the near future. Presently, this market increases by 45% annually and approximately 10,000 organizations in the United States and 1,600 organizations in Canada already use EDI (Anthes, 1990; EDI Spread the Word!, 1990). According to researchers and practitioners, the implementation of EDI will have important impacts on the economic, organizational and technological plans of business enterprises (Sokol, 1989).

However, most of the advantages related to the implementation of EDI have not yet been confirmed empirically. The investigations conducted are usually individual case studies with conclusions that can hardly be generalized to other situations (Rackoff, Wiseman and Ullrich, 1985; Clemons, 1986; Banker and Kauffman, 1988; Benjamin, De Long and Scott-Morton, 1988; Clemons and Row, 1988; Clemons and Weber, 1990; Bergeron and Raymond, 1992). There is therefore a need for an empirical study that will determine the advantages effectively achieved by the organizations that have implemented EDI and will identify the success factors associated with these advantages.

ELECTRONIC DATA INTERCHANGE

EDI saw its beginning in the United States around 1968. EDI began when two organizations started exchanging point-to-point information between their computers through private telecommunication networks. The first transactions to be transmitted were invoices and bills. Organizations transmitted these documents electronically through communication lines instead of writing and mailing them. Since the transactions did not transit through a physical mailbox, they were more rapid and the organizations saved both time and money. Partners agreed on the procedures of transmission and on the internal standards for the receiving and sending of data. The problem was relatively easy when only two partners were involved but became more complex when many partners using different computer systems, protocols and interfaces decided to exchange data through EDI (Emmelhainz, 1990).

By 1975, many sectorial business groups interested in EDI were actively working on the definition of standards. EDI standards emerged in the transportation (Transportation Data Coordinating Companies, TDCC) and food industry (Food Marketing Institute, FMI). Many working groups were established to define standards in their respective industries. In Canada, for instance, the EDI Council of Canada (EDICC) promotes the use and standardization of EDI.

The implementation of this technology brings about a certain degree of change to an organization. At the organizational level, the implementation of EDI requires the support of top management, the involvement of middle-managers affected by this technology (Harris, 1989; Monczka and Carter, 1988; Shaw, 1988; Evans-Correia, 1989), as well as the support of the supplies staff, the main user of EDI (Monczka and Carter, 1988). In this regard, training of the personnel involved constitutes a crucial step (Shaw, 1988; Harris, 1989; Canright, 1988). Indeed, any individual in the organization, from executives to staff, must understand how and to what degree EDI affects his/her work. According to Norris and Waples (1989), the implementation of EDI has the following consequences: an increase of the personnel's competence requirements, a strict separation of duties, an increase in the required authorizations, an accrued control of the communication means, and finally, a more frequent comparison of electronic records against physical assets. Moreover, according to Canright (1988), EDI can increase the importance of the information systems department insofar as it implements and operates a crucial link between the organization and its partners.

EDI is thought to provide organizations with three main types of benefits (Ferguson and Hill, 1988). Firstly, EDI allows the firm to save time and money in different ways. Operating costs decrease since transactions are carried out more quickly (Canright, 1988; Shaw, 1988). The purchase of supplies, handling and filing of documents are reduced as long as they are carried out electronically and do not require the use of paper (Canright, 1988; Monckza and Carter, 1988). Mail, telephone and inventory costs diminish (Monckza and Carter, 1988). So do manpower costs insofar as the tedious work of manipulating and filing paper documents is eliminated (Monckza and Carter, 1988; Shaw, 1988). This vision of EDI efficiency has however been recently questioned by EDI users, consultants and researchers who tend to agree that few companies have realized significant cost savings or other benefits from implementing EDI (Eckerson, 1990; Carter and Fredendall, 1990).

Secondly, EDI allows the organizations to improve the quality of service to its customers. It decreases the transmission time of transactions and the number of errors. This technology accelerates customer service and reduces the length of the sales cycle. It allows the firm to increase the professionalism of its supplies personnel insofar as the use of EDI requires precise and detailed operating procedures (Monczka and Carter, 1988; Shaw, 1988; Chain Store Age Executive, 1989; Corley, 1989).

Thirdly, EDI allows an organization to reinforce its competitive position (Canright, 1988; Norris and Waples, 1989; Evans-Correia, 1989; Bergeron, Buteau and Raymond, 1991; Swatman and Swatman, 1991). By creating tighter links between itself, its customers and its suppliers, the organization sets entry barriers to newcomers in the industry and exit barriers for trading partners. It also increases the difficulty for competitors to offer similar services. However, these strategic advantages may exist only in the short run, and might also be nonexistent if the systems are implemented under pressure from major customers or suppliers (Carter and Fredendall, 1990). Given that a growing number of organizations use the daily processing of their documents as a strategic weapon to retain their customers and increase their market share (Bakos, 1991), the fact is that many smaller organizations install it under pressure from their large clients, This questions the very existence of a strategic advantage (Johnston and Vitale, 1988). Indeed, in some cases, EDI may be more a strategic necessity than a strategic opportunity for some organizations (Lesjak, 1990); this seems to be the case, for example, in the airline and banking industries (Clemons, 1991).

We observe that researchers and practitioners alike credit EDI with a list of advantages despite the fact that few empirical studies have been conducted to confirm their existence. In those cases, advantages such as cost savings were hardly observed (Carter and Fredendall, 1990; Venkatraman and Zaheer, 1990). Given the lack of solid evidence regarding advantages brought about by EDI, we have decided to further study the impacts of EDI implementation in organizations and the influence of various factors likely to influence the outcome of this implementation. The aim of this study is therefore to answer the two following questions:

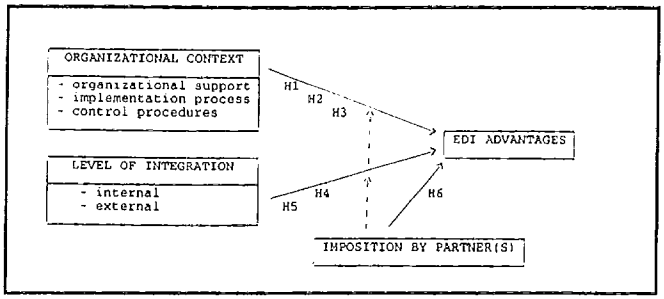
What are the advantages achieved through the implementation of EDI?

What are the success factors for the implementation of EDI?

RESEARCH MODEL AND HYPOTHESES

From the preceding observations, one can use an inductive approach to infer three groups of variables or success factors likely to condition the advantages to be obtained through EDI implementation. The first group of variables characterizes the organizational context of EDI implementation. It refers to the organizational support, the implementation process and the control procedures of EDI. The second group of variables addresses the integration or penetration of EDI, both internal and external to the organization. The last group concerns an extra-organizational issue, namely the level of imposition or coercion in the organization's use of EDI, originating from one or more of it's trading partners. The advantages of EDI constitute the dependent variable of the model (figure 1).

Figure 1
Research model and hypotheses



Organizational Support

This variable groups the elements characterizing the managerial aspects of the organizations under study as they relate to EDI (Grover, 1990; Monczka and Carter, 1988). A first element covers the training of the various persons involved in EDI including upper management, department heads, financial personnel, supplies and accounting personnel. A second element covers the degree of involvement and support of top management in the implementation process. A third element is related to the presence of an organizational structure to support EDI (Cash and McLeod, 1985). A last element refers to the level of cooperation of the personnel and the trading partners involved with EDI (Shaw, 1988).

Implementation Process

This second variable groups the activities characterizing the implementation process of EDI. A first element refers to the planning of EDI implementation (e.g., impacts of EDI, use of standards). A second element deals with the implementation approach, i.e., the development of a prototype or a pilot project (Cerveny, Garrity and Sanders, 1986). A last element addresses the evaluation process of the initial data interchanges, e.g., in-house tests, response time, error rate, transactions costs (Jezioro, 1988; Purchasing, 1988; Skagen, 1989).

Control Procedures

This third variable groups the procedures allowing the organization to control EDI. A first element refers to data integrity. It is assessed through the quality of the organizational procedures set up to protect data, e.g., transaction recording before transmission, responsibility attribution to users, back-up copies. A second element deals with the security of operations, e.g., access codes, passwords, access periods, authorized users, documentation identification (user stamp, date stamp, etc.) (Brown, 1989).

Integration

These fourth and fifth variables refer to the level of diffusion of EDI inside and outside the organization. The level of internal integration reflects the variety of applications (financial, order-entry, shipping, etc.) interconnected through EDI within the organization (Swatman and Swatman, 1991). The level of external integration illustrates the various types of trading partners (e.g., suppliers, clients, retailers) with which the organization transacts business through EDI.

Imposition

The sixth variable is the level of imposition of EDI upon an organization by its trading partners. It refers to the obligation for a firm to implement EDI in order to keep a client or supplier. This happens when one company requires that its trading partners communicate through EDI if they want to continue doing business with the company. This also can happen across whole markets or industries when vertical integration or quasi-integration is required to remain competitive. Non-compliance can then result in the loss of a partner or partners or even in the disappearance of certain organizations (Corey, 1985; Johnston and Vitale, 1988).

Advantages of EDI

This last variable, i.e., the dependent variable, groups the various advantages assumed to be obtained from the implementation of EDI (Purchasing, 1988). A first dimension covers the savings (forms costs, inventory, mail and telephone). A second dimension covers the improvement in the service to trading partners (rapidity of the service, quality of messages). A third dimension addresses the management of operations in the firm. Finally, a fourth dimension covers the benefits from the strategic repositioning of the firm due to the implementation of EDI (Banker and Kauffman, 1988; Benjamin, De Long and Scott-Morton, 1988; Bergeron, Buteau and Raymond, 1991; Bergeron and Raymond, 1992; Clemons and Row, 1988; Crowston and Treacy, 1986;

Lederer and Sethi, 1988; Porter and Millar, 1985; Rackoff, Wiseman and Ullrich, 1985; Vitale, Ives and Beath, 1986).

Hypotheses

According to our research model, six independent variables are expected to affect the attainment of advantages from EDI. The six research hypotheses are as follows:

H1: The quality of the organizational support is positively related to the advantages of EDI.

The implementation of EDI will be a success only if the organization has been formally prepared for the introduction of this new technology. This requires in particular that all personnel, from top management to EDI staff be trained and knowledgeable in the consequences of EDI implementation, and be involved in the implementation process. Training, involvement and top management support have already been shown to be essential to information system success in general (Nelson and Cheney, 1987; Doll and Torkzadeh, 1989; Bergeron, Raymond, Rivard, Gara, 1992). It is expected that this relationship will be observed in particular for EDI.

H2: The quality of the implementation process is positively related to the advantages of EDI.

Prescriptive views of systems implementation indicate that this process should be accomplished gradually by following a certain number of steps. For instance, it is important that a system such as EDI, which strongly modifies the way transactions are handled, first be tested in only one function or only one sector of the organization before its full implementation. In a survey conducted by Mahmood (1987), designers agreed that prototyping brought more benefits for the organization than the traditional system development life cycle. It is expected that, for EDI, an implementation process using prototyping or a pilot project will be more successful and thus bring more advantages.

H3: The quality of the control procedures is positively related to the advantages of EDI.

A complete and relevant set of control procedures is necessary to obtain the full benefits of EDI. These procedures should prevent errors and allow to make appropriate corrections when needed. Given the particular context of operation of EDI, which basically eliminates paper, it is necessary, for instance, to take back-up copies of all transactions (Sokol, 1989). It is contended here that an EDI system that includes security and integrity procedures will benefit the organization since it will be possible to prevent costly errors on one hand, and to rapidly make corrections to faulty situations on the other hand.

H4: The level of internal integration is positively related to the advantages of EDI

A high level of integration of EDI activities within the organization should bring various types of benefits such as economies of scale, improvements in the production cycle, and a decrease of transaction time (Swatman and Swatman, 1991). It has already been shown that organizations with a more diversified and integrated applications portfolio have more success in terms of user satisfaction and system usage (Raymond, 1985). By analogy, it can be expected that organizations that integrate their internal functions through an EDI system will obtain greater benefits.

H5: The level of external integration is positively related to the advantages of EDI.

Similarly to the preceding hypothesis, a high level of external integration should allow the organization to accelerate and tighten its communications with its partners, be they suppliers, clients, or retailers. According to Bergeron, Buteau and Raymond (1991), higher potential rewards can be obtained by firms designing and implementing strategic applications (such as EDI) with an outward rather than an inward orientation. More advantages should therefore be obtained in organizations showing a high level of integration of its external links.

H6: Organizations upon which EDI is imposed attain less advantages than those for which EDI implementation is voluntary.

Organizations upon which the use of EDI was imposed do not deliberately integrate EDI into their organizational strategy. This is evidently not an ideal situation and it is likely that less advantages will be obtained. The imposition of EDI might indeed give rise to conflict and bargaining between partners (Buzzell, 1985). In the McKesson case, for example, the implementation of EDI in the distribution network significantly affected the bargaining power of distributors (Corey, 1985).

An additional assumption of the model is that the level of imposition might act as an intervening or moderating variable in the relationship between the other independent variables and the attainment of advantages from EDI. For instance, one could assume that these relationships would be stronger among firms that have implemented EDI voluntarily and could be non significant in the case where it is imposed from outside.

METHODOLOGY

Data Collection

The sampling universe consisted of 560 Canadian enterprises. A questionnaire was mailed to the individual responsible for EDI in each enterprise. A cover letter addressed to the EDI manager was included, assuring confidentiality and explaining the objectives of the study with instructions on how to answer the questionnaire. A pre-addressed return envelope and the possibility to receive a summary of the results of the study were meant to increase the response rate.

The questionnaire was pre-tested through direct interviews with EDI managers in ten enterprises. In its final form, the questionnaire was mailed to the member-firms of the EDI Council of Canada, which had kindly provided its membership list. The questionnaire was addressed to the EDI managers when the mailing list provided this information. Otherwise, the questionnaire was sent to the members listed asking them to direct it to the EDI manager if they did not hold the position themselves. To maximize the response rate, a recall letter was sent one week after the initial mailing. A total of 168 responses were obtained, of which 140 were retained for the purposes of the study, for a response rate of 25%. Twenty-eight responses were excluded because the firms had not yet implemented EDI or had done so too recently to be able to evaluate its impact.

Measurement of the Research Variables

A number of scales were used to measure the independent variables hypothesized to influence the attainment of advantages from EDI. The organizational support, implementation process, and control procedures had 11, 12, and 14 items respectively as shown in Figure 2. The respondents were asked to rate the scales by the following statement: "Please indicate for each of the following statements the extent to which they are representative of the EDI implementation process in your organization". Each scale was anchored on three points (no:1, more or less:2, yes:3) and a total score was obtained by averaging on all scales.

The imposition scale was one item asking the respondents to evaluate the truthfulness of the following statement: "The initial decision to implement EDI was imposed by your trading partner(s)" (no:1, more or less:2, yes:3). Level of imposition thus refers only to the first EDI application implemented by the organization. The level of internal integration was determined by numbering the different types of EDI applications internal to the organization, whereas the level of external integration numbered the different types of trading partners. For that purpose, the respondents were asked to indicate the exact types of EDI applications presently implemented (e.g. purchasing, billing), as well as the types of business partners presently communicating with the organization through EDI (e.g. clients, suppliers).

Figure 2
Organizational context of EDI

Organizational Support
- training of top-management
- training of department heads
- training of data processing personnel
- training of users
- top-management is favorable
- top-management supports the implementation project
- working group responsible for implementation
- EDI managed by a specific organizational unit
- individual(s) specifically assigned to manage EDI
- cooperation with commercial partners during implementation
- cooperation among departments during implementation
- *overall quality of the organizational support for EDI'*

Implementation Process
- analysis of strategic and operational impacts of EDI
- use of pre-defined transmission standards and protocols
- availability of an EDI implementation guide
- development of a prototype before implementation
- pilot project conducted before definitive implementation
- in-house tests, i.e. only within the organization
- external tests, i.e. with trading partners
- analysis of initial transactions
- appreciation of system quality by users
- measure of response time
- measure of error rate
- measure of transaction costs
- *overall rigor of the EDI implementation process'*

Control Procedures
- transaction entry and control tasks assigned to different individuals
- transactions recorded before transmission
- transaction acknowledgements by partners are recorded
- backup of transactions
- backups stored outside the organization
- transaction entry and safekeeping tasks assigned to different individuals
- only formally authorized personnel may use EDI
- access code necessary to use EDI
- authorization required for special transactions, e.g. exceeding a certain limit
- user authorized for limited types of transactions
- transactions bear a user stamp
- transactions bear a date stamp
- transactions bear a time stamp
- transactions made only within pre-determined time period
- *overall attention given to EDI control procedures'*

'Added for criterion validity purposes

The dependent variable included various benefits that are thought to be provided by EDI, in terms of cost and time reductions, information quality, operations management and strategic advantage (22 scales), as shown in Figure 3. The EDI supervisor was asked to rate the scales by the following statement: "Please evaluate the impact of the EDI implementation relative to the functions presently supported in your organization", by indicating on a 5-point Likert scale to what extent each of these advantages had been obtained by the enterprise (strong decrease: 1, slight decrease: 2, no change: 3, slight increase: 4, strong increase: 5).

Figure 3
Advantages potentially obtained from EDI

EDI Advantages
- transaction costs
- forms costs
- forms manipulation costs
- forms storage costs
- postal costs
- telephone costs
- telecommunications costs
- office personnel costs
- transaction transmission time
- transaction processing time
- transaction errors
- inventory level
- operation cycle time
- decision cycle time
- price of products or services offered
- quality of service to clients
- timeliness of transaction information
- accessibility of transaction information
- accuracy of transaction information
- entry barriers for newcomers to the industry
- exit barriers for trading partners
- difficulty for competitors to offer similar EDI services

Note that the last seven advantage scales measuring benefits were coded in reverse direction since, for example, an increase in service quality is an improvement whereas an increase in transaction costs is a deterioration (for purpose of clarity in data analysis, the terms deterioration and improvement will be used for all advantages).

Given their initial level of face validity, additional validity of the three organizational context measures was confirmed by correlating them with an additional item asking for an overall evaluation of each trait (criterion validity), as shown in Figure 1. Correlations between organizational context variables and the three criteria were as follows: organizational support (r=.48, p=.000), implementation process (r=.51, p=.000) and control procedures (r=.41, p=.000).

RESULTS AND DISCUSSION

The results of this study are based on the 140 valid responses obtained from the data collection and measurement procedure.

Sample Characteristics

Table 1 first indicates which individual is actually responsible for EDI in the sampled organizations. This individual is a manager in 59% of the cases, most often the information systems manager. Only in 19% of the cases is the task of supervising EDI given to an individual specifically named to this function; this means that EDI generally constitutes an added responsibility for those assigned to manage it. One can also note the importance given to EDI by the fact that those who supervise this function are generally high-placed in the organizational hierarchy. In fact, 57% of these individuals report directly to the chief-executive-officer.

Table 1
Job title of the respondents and their superiors (n=140)

	Job Title		Superior's Job Title	
	%	n	%	n
President	8.7%	12	57.4%	78
IS manager	38.4%	53	21.3%	29
Manager	20.3%	28	10.3%	14
EDI supervisor	18.8%	26	0.0%	0
Other	13.7%	21	11.0%	19

The responding firms have an average size of 3,081 employees and they already have a certain experience with EDI, having implemented it 3.5 years ago on average (Table 2). In this regard, one can note that a fifth of the sampled organizations have less than 200 employees, a third have been using EDI for less than 24 months while a fourth have been using it for more than six years. Note, however, that all results pertaining to the research hypotheses, presented further in this paper, were found to be unaffected when controlling for organizational size and EDI experience.

Table 2
Characteristics of the organizations (n=140)

	mean	median	min.	max.
Number of employees	3,081	700	6	50,000
Annual sales or budget ('000$)	585,859	200,000	150	6 200,000
EDI experience (months)	30	24	1	120
Initial investment in EDI ($)	28,059	20,000	3,000	99,993
Annual EDI budget ($)	29,195	10,000	300	98,000

The initial investment in EDI is relatively low, i.e. a median value of 20,000 dollars in added hardware and software, for firms whose median sales figure is in the order of 200 million dollars. However, in comparison to the amount of investment, the annual operating budget subsequently allocated to EDI seems relatively high, with a median value of 10,000 dollars. From a previous study (Swatman and Swatman, 1991) and from the authors' personal experience with EDI implementation cases, this can be explained by the fact that this technology is implemented gradually, usually starting with a single function (either purchasing or billing) for the first year or two, then adding other functions.

As expected, the firms use EDI mostly for their purchasing and billing transactions (72% and 58% respectively, as shown in Table 3), with a significant proportion using this technology both for their downstream and upstream activities. EDI is thus at the heart of the enterprises' commercial operations, with a domain that extends to shipping, funds transfer, and other activities such as order reception, order status, shipment planning, payroll data and internal communication. As expected, the principal EDI business partners of the sampled enterprises are their clients and suppliers (in 71% and 36% of the cases respectively, as presented in Table 4). There is also a relatively wide range of additional partners, including distributors, financial institutions, shippers and others such as governmental organizations.

Table 3
Type of EDI transactions (n=140)

Type of EDI transaction	%	n
Purchasing	72.1%	101
Billing	57.9%	81
Shipping	31.4%	44
Funds transfer	12.1%	17
Other	22.9%	32

Table 4
Type of EDI business partners (n=140)

Type of EDI partner	%	n
Clients	70.7%	99
Suppliers	36.4%	51
Distributors	20.0%	28
Financ. institutions	15.0%	21
Shippers	14.3%	20
Government	10.7%	15
Other	12.1%	17

As to the specialized communication networks by which EDI transactions are transmitted, GE's GEISCO is the most prevalent, being used by more than half of the sampled enterprises (Table 5). However, it is interesting to note that many firms employ not only other specialized EDI networks such as Telecom Canada's ROUTE COMMERCE, but also their own private communication network. Also, a minority of firms simply use the public telephone network to transmit their transactions. The prevalent EDI transmission standard is ANSI X.12, being found in two-thirds of the enteprises (Table 6). Two other standards, UCS and TDCC are also significantly present, to the extent that each is used by almost a third of the sampled firms. Given the trend toward EDI standardization, this seems to favor ANSI X.12 in Canada, whereas the international standard, EDIFACT, is mostly ignored at present. Note that some firms communicate with different business partners through multiple EDI networks and standards.

Table 5
Type of EDI network (n=140)

Type of EDI network	%	n
GEISCO (GE)	51.4%	73
ROUTE COMMERCE (Telecom Canada)	26.4%	37
IBM	8.6%	12
Other	34.3%	48

Table 6
Type of EDI standard (n=140)

Type of EDI standard	%	n
ANSI X.12	65.0%	91
TDCC	27.1%	38
UCS	23.6%	33
EDIFACT	5.0%	7
Other	5.0%	7

Determining the Advantages of EDI

A principal components analysis (varimax rotation) was made to determine the number and nature of the factors or dimensions that are found in the "EDI advantages" construct. A five-factor structure was found, explaining 61% of the variance; as shown in Table 7, all of the advantage scales save one had a loading greater than 0.5 on the factor to which they were attributed. One scale, relating to telecommunication costs, was removed because it did not load on any one factor. A measure of the internal consistency of each factor, Cronbach's alpha, indicates an adequate level of reliability for each factor, 0.5 being the minimum level required for exploratory work (Nunnally, 1978). The five categories of EDI advantages found by the factor analysis are thus the following:

- a first category, which can be named "administrative costs", relates to cost reductions in terms of transactions, forms, forms manipulation and filing, office costs and inventory levels;
- a second category, "information quality", concerns reductions in transaction errors, and improvements in the quality of service to clients, and in the timeliness, accessibility and accuracy of transaction information;
- a third category, "operations management", refers to reductions in the length of the operations and decision-making cycle, and in the price of goods or services offered;
- a fourth category, "strategic advantage", relates to the creation of barriers for newcomers and difficulties for competitors, and to the tightening of relationships with commercial partners;
- a fifth category, "transaction speed", concerns reductions in the time required to transmit and process a transaction.

Table 7
Factor analysis of the dependent variable (n=140)

Factor	1	2	3	4	5
EDI advantages	Admin. Costs	Inform. Quality	Oper. Manag.	Strateg. Advan.	Trans. Speed
Transaction costs	.71				
Forms costs	.74				
Forms manipulat. costs	.82				
Forms storage costs	.77				
Postal costs	.66				
Telephone costs	.53				
Office personnel costs	.47				
Trans. transmission time					.85
Trans. processing time					.62
Transaction errors		.55			
Inventory level	.56				
Operation cycle time			.76		
Decision cycle time			.80		
Products/services' price			.71		
Client service quality		.82			
Information timeliness		.85			
Information accessibility		.81			
Information accuracy		.79			
Entry barriers for newcomers				.59	
Exit barriers for partners				.65	
Difficulty for competitors				.63	
eigenvalue	5.9	2.8	1.9	1.5	1.3
% of variance	26.9	12.9	8.8	6.6	6.0
Cronbach's alpha	.84	.86	.68	.50	.69

For every organization, a value was obtained for each of the five advantage categories by averaging the related scales. An overall value (global advantage) was also obtained by averaging on all 21 scales, with an alpha of .85 confirming the reliability of the measure. Note that the face validity in the factor structure is due in part to the order in which the scales were presented in the instrument. While this represents a certain amount of methods bias, it was deemed to be nonetheless preferable to a random ordering that would have irritated and confused the respondent, given that each scale requires a certain amount of thought before it can be answered adequately and that the last seven scales were presented in opposite direction to the others.

Obtaining Advantages From EDI

Looking at this factor structure (Table 7), one could characterize EDI advantages as being either at the operational level (administrative costs and transaction speed factors), the managerial level (information quality and operations manage-

ment factors) or the strategic level (strategic advantage factor). The results in Table 8 show the extent to which the enterprises have obtained the various advantages provided by EDI. Given the central role of EDI in the literature on strategic information systems, it is interesting to note that the organizational benefits actually provided by this technology were perceived by the respondents to be operational and managerial rather than competitive in nature. One must also note the the mean scores for all EDI advantages (3.2 to 3.7) are near the neutral point (3.0: no change). However, the null hypothesis that there is no significant advantage, i.e. that the mean is equal to 3.0, was rejected with the mean score for each type of EDI advantage being greater than the upper limit of the corresponding 95% confidence interval for the neutral point, as shown in Table 8. Therefore it can be concluded that, on average, the sampled organizations obtained positive results from their EDI applications. Nonetheless, the attainment of a strong advantage from EDI is the case for only a minority.

Table 8
Descriptive statistics of the dependent variables (n=140)

EDI ADVANTAGES	mean[a]	s.d.	min.	max.	limit[b]
Administrative costs	3.36	0.5	2.3	5.0	3.08
Transaction speed	3.58	1.1	1.0	5.0	3.18
Information quality	3.69	0.7	1.4	5.0	3.11
Operations management	3.22	0.5	1.3	4.7	3.08
Strategic advantage	3.23	0.5	2.0	5.0	3.08
Global advantage	3.43	0.4	2.6	4.6	3.07

[a] 1=strong deterioration 2=slight deterioration 3=no change 4=slight improvement 5=strong improvement
[b] Upper limit of 95% confidence interval for mean=3.00 (neutral)

The measures of the first three independent variables hypothesized to affect the attainment of EDI advantages were found to be reliable, with Cronbach's alpha being respectively equal to 0.72 for organizational support (11 scales), 0.69 for implementation process (12 scales) and 0.75 for control procedures (14 scales). Table 9 shows the extent to which the sampled firms have preoccupied themselves with the organizational context when implementing EDI. These results indicate that in general, the implementation was relatively well prepared and well executed by the sampled organizations, and that EDI is operated with an adequate concern for data integrity and security, with all three variables averaging approximately 2.5 on the previously described three-point scale.

Table 9
Descriptive statistics of the independent variables (n=140)

	mean	s.d.	min.	max.
ORGANIZATIONAL CONTEXT[a]				
Organizational support	2.50	0.3	1.6	3.0
Implementation process	2.40	0.4	1.2	3.0
Control procedures	2.43	0.4	1.2	3.0
LEVEL OF INTEGRATION				
Internal integration[b]	1.36	0.9	1	5
External integration[c]	1.79	1.1	1	6
IMPOSITION BY PARTNERS[d]	0.64	-	0	1

[a] 1=no 2=more or less 3=yes
[b] types of EDI transactions made by the organization
[c] types of EDI partners linked to the organization
[d] 0=EDI implementation is voluntary
1=EDI is imposed by one or more business partners

Table 9 also shows the extent to which EDI is presently integrated in the studied firms, both internally and externally. The average organization uses EDI to make two different types of business transactions, and has links with two different types of business partners. Some, however, have pushed EDI integration much further, using EDI for as many as five categories of transactions, and with as many as six categories of partners.

As to whether EDI implementation is voluntary, one can see that this is not the case for a majority of firms, with 64% reporting that their use of this technology was imposed upon them by one or more of their business partners. Approximately two out of three firms in the sample thus seem to have been reactive rather than proactive in regard to EDI. Implementing this technology thus constitutes a strategic necessity in most cases, rather than a strategic opportunity (Clemons and Row, 1988). Note that the imposition variable was dichotomized for data analysis purposes (no:0; more or less, yes:1) and as such, can be treated as an interval-level measure, including its use in the product-moment (Pearson) correlation coefficient (Nie et al., 1975, p. 5).

The intercorrelations for the two sets of organizational context and level of integration variables are presented in Table 10. These results, showing relatively strong intra-set relationships and weak inter-set relationships, indicate that one could view each set as one factor in further analysis. Note however that a higher level of EDI integration tends to be accompanied by greater control over the organization's electronic transactions, given that these transactions affect more business functions and partners.

Table 10
Intercorrelations of the Organizational context and Integration variables (n=140)

	ORGANIZATIONAL CONTEXT			INTEGRATION
	Org. support	Impl. process	Control procedures	Internal integration
ORGANIZATIONAL CONTEXT				
Org. support	-			
Impl. process	.47***	-		
Contr. procedures	.29***	.46***	-	
LEVEL OF INTEGRATION				
Int. integration	.10	-.02	.19**	-
Ext. integration	.09	.02	.14*	.60***

*: p < .05 **: p < .01 ***: p < .001

Hypotheses 1 to 5

In answering the second research question, one must determine if the firms that have obtained greater advantages are the ones who have provided a more appropriate context for the implementation and use of EDI (H1, H2, H3) and have more fully integrated EDI in their various commercial activities (H4, H5). In Table 11 are found the zero-order correlation coefficients between the independent and the dependent

variables in the research model (Figure 1). Looking first at the left-hand column, there is a positive and significant relationship between all five implementation and integration context variables, and the global attainment of advantages from EDI. These results confirm overall the related research hypotheses, and thus the necessity for the organization to preoccupy itself with the manner in which it implements and integrates EDI if it wants to fully realize the benefits of this technology.

Table 11
Zero-order correlation coefficients of the independent variables with the dependent variables (n=140)

	EDI ADVANTAGES					
	Global Advan.	Admin. Costs	Trans. Speed	Inform. Quality	Oper. Manag.	Strateg. Advan.
ORGANIZATIONAL CONTEXT						
Org. support	.26***	.30***	.12	.13	.18*	-.05
Impl. process	.25***	.30***	.21**	.15*	.10	-.21**
Contr. procedures	.21**	.31***	.20**	.04	.11	-.11
LEVEL OF INTEGRATION						
Int. integration	.28***	.35***	.10	.10	.02	.21**
Ext. integration	.29***	.29***	.20**	.10	.10	.21**
IMPOS. BY PARTNERS	-.29***	-.35***	-.05	-.11	-.20**	-.10

*: p < .05 **: p < .01 ***: p < .001

Examining the other columns of Table 11 for a more detailed analysis related to specific advantages, it appears clearly that it is the attainment of operational benefits that is most affected by the organizational context, especially in terms of administrative costs as very significant relationships are found between this advantage and all independent variables. Again, this means that greater cost reductions have been obtained by firms that have given more attention to the planning, organization, control and integration of EDI. This a also true to a somewhat lesser extent for another operational advantage, transaction speed, as it is significantly related to the implementation process, the control procedures and the level of external integration.

The attainment of managerial benefits from EDI seems to be much less affected however, as only two significant and positive relationships are found, i.e. between organizational support and operations management, and between implementation process and information quality. In the former case, one can surmize that a well organized EDI function and training of managers allows them to better integrate EDI within their decision-making. In the latter case, the information provided by EDI is relevant to the extent that global needs have been analyzed beforehand and that a prototyping approach has been used to promote organizational learning in the determination of more detailed needs.

Looking at the right-hand column of Table 11, one sees that integration, both internal and external, is the determining factor in achieving strategic benefits from EDI. This is not really surprising, given that the other factors pertain to *how* EDI is implemented and operated rather than to *what* purposes it is used for. Thus, while an efficient implementation leads to operational advantages, a strategic or competitive advantage can only be obtained through the effective application of EDI. An important dimension of this effectiveness is the extent to which EDI integrates more intra and inter-organizational aspects of the business, i.e. in the value chain (Porter, 1985) and in the relationships with clients, suppliers and other strategic targets of the firm (Wiseman, 1988).

One must also note the significant but negative relationship between the implementation process and strategic advantages. Contrary to what was hypothesized in this study, it would seem that firms who have taken greater care in implementing EDI have been less advantaged in competitive terms. In addition to the limited level of reliability and content validity of the measure used here for strategic advantages, another possible explanation would be that a more rigorous implementation process increases the time it takes to start-up EDI operations. The firm which does this would have a higher chance of being preceded by its competitors, and thus be in a less favorable competitive position.

Hypothesis 6 and the Effect of Imposition

The results presented on the bottom line of Table 11 confirm that organizations which implement EDI because they have to, not because they want to, obtain significantly less advantages overall (H6). This is the case specifically for administrative costs and operations management benefits. Here, the reduction in costs for the firm that originates EDI could be made partly at the expense of the firms upon which it imposes this technology. In the same way, the faster operations and decision-making cycle of the originating organization would not be matched by the ones receiving EDI without adequate preparation. However, since the research model assumes the imposition level to have both a direct and an indirect effect, one must examine the relationship of this variable with the other independent variables, and its moderating influence on the other hypothesized relationships.

The breakdown of the implementation and integration variables by EDI imposition level (imposed versus voluntary) is presented in Table 12. It is shown that firms who had to adopt this technology under pressure from clients, suppliers or others provide a significantly worse implementation and usage context for EDI in terms of organizational support, implementation process and control procedures. This would probably be due to the lack of proper motivation and preparation, and the inadequacy of available resources when EDI must be implemented without sufficient advance warning, simply because a major partner or partners require it.

An added research hypothesis, assigning a moderating effect to the EDI imposition variable, was tested by calculating partial correlation coefficients. Table 13 presents the results of removing the effect of imposition from the relationship between the other five independent variables and EDI advantages. As there are no basic differences in the strength and significance of the partial correlations when compared to

the zero-order correlations of Table 10, this negates the potential moderating role of imposition.

Table 12
Breakdown of independent variables by Imposition (n=140)

	IMPOSED EDI mean (n=89)	s.d.	VOLUNTARY EDI mean (n=51)	s.d.	t value (2-tail)
ORGANIZATIONAL CONTEXT					
Organizational support	2.46	.33	2.58	.27	2.28*
Implementation process	2.36	.46	2.53	.36	2.29*
Control procedures	2.39	.43	2.52	.35	2.00*
LEVEL OF INTEGRATION					
Internal integration	1.91	.84	2.06	1.07	0.87
External integration	1.67	.99	1.98	1.32	1.68

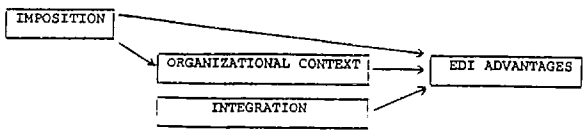
*: p < .05

Table 13
Partial correlation coefficients of the independent variables with the dependent variables (n=140)

	EDI ADVANTAGES					
	Global Advan.	Admin. Costs	Trans. Speed	Inform. Quality	Oper. Manag.	Strateg. Advan.
ORGANIZATIONAL CONTEXT[a]						
Org. support	.22**	.26***	.11	.11	.15*	-.07
Impl. process	.21**	.25***	.21**	.13	.06	-.23**
Contr. procedures	.18*	.27***	.19*	.02	.08	-.13
LEVEL OF INTEGRATION[a]						
Int. integration	.26***	.35***	.10	.10	.01	.20**
Ext. integration	.26***	.26***	.20**	.09	.08	.20**
IMPOS. BY PARTNERS[b]	-.22**	-.28***	.02	-.07	-.16*	-.13

[a] controlling for Imposition by partners
[b] controlling for Organizational support, Implementation process, Control procedures, Internal and External integration
*: p < .05 **: p < .01 ***: p < .001

Inversely, the bottom line of Table 13 shows the result of removing the effect of the other five independent variables from the relationship between the level of imposition and EDI advantages. Here again, when comparing with the bottom line on Table 11, no differences exist between partial and zero-order correlations. Overall, this seems to indicate that imposition has not only a direct effect on EDI advantages but also an indirect effect through the organizational context, as depicted below.



These last findings thus constitute the main divergence from the initial research model and should lead to further enquiry on the EDI imposition variable.

Multivariate Analysis

The analyses presented in the previous section examine the hypothesized bivariate relationships between EIS advantages and each independent variable. In order to summarize the impact of the research model's independent variables and to test for the interaction effect of the imposition variable, stepwise regression analyses were performed. Table 14 presents the results of these six analyses (one for each type of advantage, including global advantage).

Table 14
Stepwise regression on each of the EDI advantage variables (n=140)

	EDI ADVANTAGES (dependent variables)					
(standard. betas)	Global Advan.	Admin. Costs	Trans. Speed	Inform. Quality	Oper. Manag.	Strateg. Advan.
Org. support						
Impl. process	.20*	.53***		.15*		-.23**
Contr. procedures			.20*			
Int. integration	.28***	.36***				
Ext. integration			.17*			.29**
Impos. by partners	-.22**				-.19*	
Significant interactions of Imposition with other indep. variables						
Impl. proc. x Impos.		-1.07*				
Ext. integ. x Impos.						-.18*
Multiple R	.44	.56	.28	.15	.19	.35
R square	.19	.31	.08	.02	.04	.12
F	10.2	14.6	5.6	2.9	5.2	5.9
(p)	(.000)	(.000)	(.004)	(.089)	(.024)	(.001)

(p < .10 (p of F-to-enter set at .10 for this regression)
*: p < .05 **: p < .01 ***: p < .001

The model seems to better explain variations in the administrative costs advantage than in any other type of advantage obtained from EDI. Indeed, this is where the best results are found in terms of percentage of explained variance (R^2=.31). The model also seems to be valid when predicting the attainment of a global advantage (R^2=.19). In this case, the lower predictive capability is related to the lack of discrimination for the specific type of advantages, given that the model does not explain much variation in the other types, transaction speed, operations management and information quality in particular.

In regard to the most important predictors of EDI advantages identified by the model, results vary somewhat depending upon the type of advantages considered. However, based on the global advantage regression, these predictors are the implementation process, the level of internal integration and the level of imposition by trading partners (the latter having a negative effect on advantages). Due to the presence of some multicollinearity (Table 10), other variables found to be related to EDI advantages in the preceding bivariate analyses did not enter in the regressions and are thus not considered to be important predictors. Returning to the level of imposition, the small number of significant interactions observed in the regressions (2 out of a possible 30), including none in the global advantage regression, confirm the prior conclusion that there is no interaction effect of the imposition variable.

Limitations

Apart from the known constraints of the survey sampling and data collection method, this study has some limitations that must be mentioned before concluding. One concerns the need to increase the reliability and validity of the instrument used to measure the dependent variable, and in particular the strategic dimension of EDI. The other concerns the subjective, perceptual nature of the measure itself as opposed to more objective, quantitative evaluations of benefits such as cost reductions and productivity increases. There is also the reliance on one informant only, the individual responsible for EDI who, given his functional and hierarchical location, might be tempted to inflate his evaluations or might not be in the best position to estimate certain types of advantages, especially those of a competitive or strategical nature.

CONCLUSION

The findings of this study have implications for organizations who will be implementing EDI in the future, be it more or less voluntarily, and for the practitioners who are entrusted with this task. It has been empirically confirmed here that realizing the promises of EDI is neither automatic nor easy to achieve. Many firms in our sample indicate that they have not benefited from implementing EDI, and that they have in fact been disadvantaged by it. The more successful firms are the ones who have implemented EDI in a more rigorous manner, and have made it a more integral part of their business operations, management and strategy.

More specifically, the attainment of operational benefits is subject to the provision of organizational support for EDI in terms of top-management implication, training for all individuals concerned, structuring the EDI function, and insuring the collaboration of all departments and business partners involved. The EDI implementation process is also shown to be crucial, as the more successful enterprises have taken care to analyze the operational and strategic impacts of EDI beforehand. They have proceeded gradually and prudently by adopting a prototyping approach to system development, and stressing quality control with appropriate tests and performance measures. Given the impact of EDI on operations, more advantages have been attained by firms who have implemented control procedures, thus insuring the integrity and security of transaction data. The use of EDI standards was also revealed to be important. In this regard, the definition and use of EDI standards and norms should continue to facilitate the implementation of EDI-based systems in the future. However, even though ANSI X.12 is by far the leading standard in Canada and the United States, the evolution of the EDIFACT standard should be closely observed by organizations intending to implement trans-national systems. Indeed, EDIFACT has been adopted in Europe and might become the leading international EDI standard.

A well-done implementation, while necessary, is however not sufficient to insure the realization of what is claimed to be the most important advantage of EDI, namely the competitive advantage.

At the outset, one should look at the organization and its environment as a whole, taking a systemic rather than analytic approach in identifying opportunities that can be seized with this technology. This implies that EDI can be applied with a sufficient level of integration only through a fundamental rethinking of how the organization does business.

In conclusion, this study has produced interesting results on the extent to which organizations do benefit from EDI at present, and on the implementation factors that render EDI more effective. Further research is needed however, to better understand the nature and determinants of successful EDI implementation and usage, particularly in strategic terms. Case studies of a longitudinal nature should be done to obtain a deeper understanding of the causal relationships between the variables in the research model. Finally, a fruitful approach could be to integrate this research within a more general conceptual framework, using for instance diffusion of innovation theory.

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