

Determinants and Outcomes of Electronic Data Interchange Integration

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Abstract

Electronic Data Interchange (EDI) has the potential to alter the exchange of business documents between organizations as well as their internal structures and processes. Drawing upon the research of information systems implementation and EDI-specific research, this paper defines a model which examines the role of several factors related to external environment and the organizational context in influencing the extent to which EDI is integrated, and whether more extensive integration has an impact on organizational outcomes. The research model identifies a set of variables as the key factors that could explain the EDI integration and its expected impact. EDI integration is represented by two dimension: internal and external. The impacts of EDI constitute the dependent variable of the model. The effectiveness of the model is demonstrated by the development of twenty-two propositions that could be tested in practice.

Resume

Electronic Data Interchange (EDI) hat die Fähigkeit, den Austausch von Geschäftsdokumenten zwischen Organisationen zu beeinflussen, sowie deren interne Strukturen und Prozesse. Basierend auf Studien über die Implementierung von Informationssystemen und spezifischen Studien über EDI, stellt dieser Beitrag ein Modell dar, das die Rolle und den Einfluss von verschiedenen externen und organizationinternen Faktoren eines EDI-Integrationsumfeldes analysiert. Ausserdem wird untersucht, inwiefern eine breitere Nutzung des EDI die Ergebnisse der Organization beeinflusst. Dieses Forschungsmodell identifiziert eine Gruppe von Variablen, sowie die ausschlaggebenden Faktoren, die die Integration und Auswirkung dieser Technologien erklären kann. Die Integration der EDI repräsentiert sich in zwei Dimensionen: intern und extern. Die Auswirkung vom EDI ist die abhängige Variable des Modells. Die Richtigkeit des Modells ist durch die Entwicklung von 22 Voraussetzungen, die man auf empirische Weise überprüfen kann, bewiesen worden.

1. Introduction

The information technology (IT) has the potential to alter the exchange of business documents between organizations as well as their internal structures and processes. One particular type of interorganizational network technology with which these ideas

are strongly associated is Electronic Data Interchange (EDI), one type of strategic interorganizational system. EDI is "the process of direct computer-to-computer communication between a business entity and its trading partners of business documents and information in a machine readable, structured format that permits data to be transferred from the sender and used by the receiver without rekeying" (Hansen et al. 1989). EDI's direct impacts are to reduce the amount of data capture and transcription, and the delay between dispatch and receipt of messages. These often result in a decreased incidence of errors, less time spent on exception-handling, and fewer data-caused delays in the business process. Benefits can be attained in inventory management, transport and distribution, administration and cash management. However the most significant benefits from EDI can only be obtained from a closer integration among related processes within organizations. The replacement of paper by electronic messaging which provides EDI's strategic potential, but the associated changes in processes operation within or between organizations which EDI links make possible. Therefore the key factor for the effective use of EDI is the organization's ability to manage the changes in the structure and work processes (Benjamin et al., 1990).

The early research on EDI highlighted how the large enterprises, generally the EDI sponsor, derived competitive advantage. This research was often based on case studies of few organizations (for example, Benjamin et al., 1990; Swatman et al. 1993). In these cases, the trading partners of the studied organizations had occupied a passive role and the studies gave them only cursory attention (Nygaard et al. 1994). Theoretical research has used different approaches to examine the implementation of EDI, the benefits from this technology, and industrial restructuring toward electronic markets. However, some studies are based on narrow definitions and restraining sets of assumptions that may be impractical in the real world. There have been some empirical studies that have examined the factors influencing the adoption of EDI and the benefits from this technology (for example, Banerjee et al. 1994; O'Callaghan et al. 1992). They have primarily looked at adoption and have examined neither the integration process nor its impact. One exception could be the study conducted by Bergeron et al. (1992), where the potential benefits from EDI are linked to the level of integration both internal and external. They argued the level of integration is a critical factor for obtaining benefits from EDI usage. Similarly, Salvador et al. (1995) established the external integration should include each trading partner and governed by stable and long-term relationships.

However, the research has only focused on the relationship between environment and/or organizational context and integration process, or between integration process and benefits or advantages from EDI. The disadvantage of the decomposition of mutually influencing factors is that those factors generating synergy effects are separating from the context which gives them meaning. This study tries to fulfill this gap, and therefore, the objectives of this study are twofold:

- To examine the impact of several factors related to external environment, and the organizational context on EDI integration, and

- to examine the relationship between EDI integration and the several outcomes.

This paper is focused on the development of the research model, and does not present the interim findings of the study, which is still in progress. In section 2, the paper discusses the background literature which provides the basis for the model. The research model and hypotheses are developed in section 3. These are followed by conclusions.

2. Literature review

Two areas of research have provided the necessary theoretical foundations for this study: information systems (IS) implementation and EDI-specific research.

2.1 Information systems implementation

The research in IS implementation has emphasized the critical role that top management support plays in ensuring success. A committed top management support can positively influence the project selection and its successful implementation where as its lack has often been cited to be a barrier to effective use of systems. Top managers often play a crucial role in overcoming resistance to the new technology, organizing needed resources and being closely involved in the phases of adoption, implementation and transfer of the project.

IS research has also proposed that the capability of the IS function in terms of its competence is positively associated with IS success (IS sophistication as Raymond (1988) calls it). In its most ideal form, EDI includes movement of interfirm business transactions to the internal systems in a seamless way. The IS competence is a crucial element to satisfactory accomplish such a major technical goal and enable the firm to reap the full range of EDI benefits.

While many organizations have adopted EDI in response to genuine need and/or external pressures, successful integration requires that the organization adapts the processes, work practices and manages the technology transfer. Successful implementation and integration of IT requires that the personnel within the adopter organization learn new ways to perform its tasks. This requires significant degree of learning to occur within the adopting organization over extended time periods.

2.2 EDI research

The research on EDI can be classified into two broad groups: theoretical/analytical and field-based empirical research. In the first category, the potential adoption behavior of individual firms and the diffusion of EDI at the industry level are mathematically modeled. This line of research draws primarily from information economics,

microeconomic production, industrial organization economics and others applied theories. Using transaction cost theory, it has been posited that due to reduced cost of coordination through EDI, market transactions between trading partners may eventually migrate away from vertical/hierarchical relationships to one of electronic marketplace. Mukhopadhyay (1993) reviews the EDI literature, and discusses methods to measure the economic benefits of EDI to adopter organizations. Wang et al. (1991) build in the identity of participants in addition to the number of participants in the network and develop a two-level hierarchical model for a single buyer with competing heterogeneous set of suppliers. They argue that regardless of the buyer's policy, subsidy or mandating, it will be only the buyer and the end consumers who may benefit from EDI adoption by suppliers rather than the suppliers themselves and that a partial adoption by the supplier base may be optimal for the buyer.

For the field-based empirical research, the mayor theory bases have been: competitive effects of IT, sociopolitical framework for interorganizational relationship, innovation adoption and diffusion, and IS implementation. Venkatraman et al. (1990) examined whether the business of the insurance carrier would be enhanced by agents who were electronically integrated vis-à-vis those who were not, and found only weak support for electronic integration's beneficial effects. Drawing on theoretical and empirical research of transactions costs, Venkatraman et al. (1994) developed and tested a model of the determinants of the degree of electronic integration in the commercial segment of the property and casualty industry. Using data from 120 independent agencies, they found support for asset specificity and trust in explaining the degree of electronic integration, while reciprocal investment is only weakly significant.

Using the IS implementation and innovation adoption literatures, O'Callaghan et al. (1992) examined the role of compatibility, relative advantage, and external influences on EDI adoption decision of insurance agents. They also examined the post-adoption effects of EDI in terms of improved buyer-seller relationships and therefore the increased proportion of business the seller did with EDI-linked buyers. This field study of 1242 insurance agents found relative advantage to be only variable influencing adoption decision and that adoption did indeed enhance the carriers' business from EDI-interfaced agents. Cragg et al. (1993) determined that perceived relative advantage of EDI (i.e., perceived EDI benefits and impact) is the only variable that has been consistently identified as one of the most critical adoption factors and as the most important factor for IT growth in small firms.

Banerjee et al. (1994) attempted to develop profiles of users versus non-users of EDI and proposed the key motivating factors as well as difficulties that have a bearing on the EDI adoption decision based on a sample of 62 firms. Hwang et al. (1992) undertook a large field study of 229 firms and examined the influences of three structural factors (for example, size of the firm) and eight organizational and industry factors (for example, championing, involvement of users\traders\vendors, user and trader training, EDI standard use) on implementation success, and the influence of structural factors and implementation success on competitive benefits. Drawing upon research on innovation diffusion and IS implementation, Ramamurthy et al. (1995)

examined the role of key innovation and organizational factors in influencing the extent to which EDI is diffused within organizations, and whether more extensive diffusion leads to improved organizational outcomes.

From the study of EDI in 140 Canadian firms, Bergeron et al. (1992) conclude that the more successful firms have provided more organizational support for EDI in terms top management involvement, training for all personnel concerned, structuring of the EDI function, and insuring the collaboration of all stakeholders involved. Raymond et al. (1995) based on a sample of 15 Canadian small and medium-sized firms examined the influences of four factors on the potential of EDI within a network of small and medium-sized firms. Based on a review of the literature on EDI adoption and small business IT, Iacovou et al. (1995) identified three factors (perceived benefits of EDI, organizational readiness, and external pressure) as the main reasons that could explain the EDI adoption behavior of small firms and the expected impact of the technology.

3. Research model and hypotheses

The research model has been proposed based on research in IS implementation and EDI-specific research. It addresses the two objectives of this study.

The research model identifies a set of external and organizational variables as the main reasons that could explain the EDI integration into the organizations and the expected impact of this technology. The first group of factors characterizes the external environment in which the organization operates. The second group of factors characterizes the organizational context of EDI implementation. It refers to organizational maturity, IT maturity, rationale for implementing EDI, top management support, and implementation process. The third refers to managers' perceived benefits before any EDI implementation, i.e. to the level of recognition of the relative advantage that this technology can provide the organization.

The fourth group of variables addresses the integration of EDI into the organization. EDI integration is represented by two dimension: internal integration and external integration. Internal integration refers to the variety of applications interconnected through EDI, and external integration refers to the number of trading partners with which the firm can transact business through EDI (Bergeron et al. 1992). EDI integration is a variable both dependent (left side of the model) and independent (right side of the model).

The last group includes a context variable, namely the size of the organization, and an extra-organizational variable, namely the level of imposition in the organization's use of EDI, originating from one or more of its trading partners.

The impacts of EDI constitute the dependent variable of the model. The outcomes show the influence of the depth of EDI integration on on the organizational boundaries, on the relationships with others enterprises connected EDI network, and

on its market position. The relationships of this factors with the process of EDI integration, and impact are shown in figure 1.

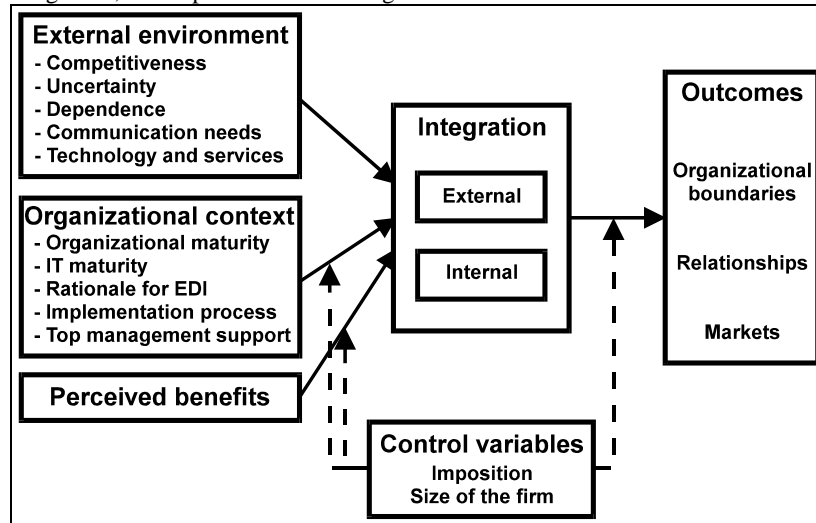


Figura 1: Research model

3.1. Hypotheses

3.1.1 Environment

There are certain key factors in the environment which influence positively the way in which EDI is adopted, integrated and used (Grover et al. 1993). Factors such as the level of uncertainty in an environment, competition characteristics, market deregulation, interorganizational dependence, communications needs, value-added network services and the technology itself play a critical role in EDI adoption and integration. Achrol et al. (1983) conceptualized the environment as a dynamic reality without a well-defined shape, size or elements. Consequently, the following hypotheses could be proposed:

- H1a: The factors related with the economic and technological environment will be positively related to EDI's internal integration.
- H1b: The factors related with the economic and technological environment will be positively related to EDI's external integration.

3.1.2 Organizational maturity

Ein-Dor et al. (1978) had hypothesized that greater organizational maturity increased the likelihood of IS success. Raymond (1988) based on a sample of 34 Canadian small and medium-sized firms concluded that a higher level of organizational maturity creates a more favorable environment for the successful implementation of IS. Swatman et al. (1991) argued that a high level of both organizational maturity and IT maturity increase the probability of success in IT adoption process. Scott Morton (1991) and Galliers et al. (1991) describe characteristics identifying organizations capable of proactive, integrated and strategic use of IT, in general, and EDI, in particular.

H2a: The organizational maturity will be positively related to EDI's internal integration.

H2b: The organizational maturity will be positively related to EDI's external integration.

3.1.3 IT maturity

IT maturity is defined as the organization's technical and managerial competence for adopting and integrating IT-based solutions to achieve business objectives. In the context of EDI, communications infrastructure is critical, but it is also critical that this is backed by suitable IS infrastructure so that electronic business transactions can be done with minimal human intervention. To successfully accomplish and ensuring a seamless integration requires high experienced IS staff. However, the standards, software, and technologies used in EDI are quite different from those in the internal IS. IT competence is a critical factor to facilitate extensive integration of EDI between and within the organizations.

H3a: The IT maturity will be positively related to EDI's internal integration.

H3b: The IT maturity will be positively related to EDI's external integration.

3.1.4 Top management support

Top management vision, commitment and support have almost always emerged as a key factor in IS implementation success. Active involvement and support of top management provides the appropriate strategic vision and direction about the importance of this technology for the organization's business. Given the potential for EDI to influence the firm's competitive position as well as its business relationships, the need for top management to get intimately to gain a good understanding of the involved stakes and mobilize commitment of other stakeholders is important (Sokol 1989). Thus, the organization will increase its functional coverage of EDI.

Top management involvement is also required to persuade the firm's trading partners to use EDI as a means of communicating business transactions and convince them on its benefits and advantages. Thus, the organization will increase the business

support of EDI, given the expansion of the set of business transaction, and the increase of the proportion of trading partner with which the electronic communication is realized. Also, no organization has unlimited resources, and therefore, an EDI project requires the top management commitment and support for obtaining the necessary resources.

H4a: The top management commitment and support will be positively related to EDI's internal integration.

H4b: The top management commitment and support will be positively related to EDI's external integration.

3.1.5 Rationale for implementing EDI

There can be several reasons both operational and strategic for organizations to join an EDI network, and they should be consistent with the strategic vision of the organization. EDI may be used to cut costs and improve internal and external information flows with the aim of improving process coordination, increasing data accuracy, reducing or eliminating administrative overheads, etc. But when the organizations try intentionally to minimize changes in work practices in an attempt to obviate resistance to the new system or work practice, EDI is not integrated into involved processes and is only considered as an expensive fax machine. Many firms think that it will be enough to have just one business partner, if this relationship represents enough transaction volume to justify the investment.

Also, EDI may be used in order to pursue particular business strategies. These may even include the introduction of business network redesign and an outsourcing of certain tasks or processes, in which the supplier base is rationalized while the relationships are made more collaborative and stable. To obtain an optimal level of efficiency will require a seamless integration between EDI system and internal IS and applications, and all involved processes have been either simplified or redesigned. Also, the external integration is crucial to justify the investment.

H5a: The rationale for EDI will be positively related to EDI's internal integration.

H5b: The rationale for EDI will be positively related to EDI's external integration.

3.1.6 Implementation process

There is no controversy that EDI can and do provide a number of tangible and strategic benefits. However, these benefits are feasible depend on the organization's ability to manage the changes both technical and organizational for integrating EDI with internal IS applications as well as with its trading partner base. For example, the work procedures and practices should be changed, the business documents should be redesigned, the trading relationships should be redefined, and the personnel should be trained to achieve a wider integration. These changes can only be implemented in

planned and incremental manner. One cannot automatically assume that early adoption would lead to complete integration and wider benefits. It is likely that many firms have adopted EDI influenced or forced by their major partners. These firms do not have incentives to diffuse it any further by expanding its use with other partners or with their internal IS applications. The empirical research has indicated mixed results. While Reich et al. (1990) pointed out that an early adoption did not necessary lead to a greater integration, Hwang et al. (1992) and Swatman et al. (1991) found positive results. However, the ability of early adopters for conducting the learning process and taking advantage of their experiences can be a key factor in their integration efforts.

H6a: The time elapsed since initial adoption will be positively related to EDI's internal integration.

H6b: The time elapsed since initial adoption will be positively related to EDI's external integration.

Most firms have adopted EDI technology through pilot projects. These are essentially processes designed to facilitate organizational learning. The focus is on making the technology work and managing its impacts on the organization. The exceptions would be those firms to which EDI is imposed. Because they are excluded from this learning process, they only automate some processes, but do not improve them (Webster 1995). Therefore, it will be an impediment for further full integration.

H7a: The knowledge and experience about EDI will be positively related to EDI's internal integration.

H7b: The knowledge and experience about EDI will be positively related to EDI's external integration.

Imposition is a type of external pressure often applied and used by large corporations (generally, EDI sponsors) to achieve a fast diffusion of this technology in the industries (Nygaard et al. 1994). However, a forced diffusion shows negative effects in the firms that had been forced to use the system, for example, the implementation of minimal solution between the organizations. Therefore, there is no motivation or incentives for integrating EDI both internally and externally.

H8: The imposition will be negatively related to the extend of its internal and external integration of EDI.

3.1.7 Perceived EDI benefits

Perceived EDI benefits refer to the level of recognition of the relative advantage that EDI technology can provide the organization. Higher managerial understanding of the relative advantage of EDI (i.e., direct and indirect benefits) increases the likelihood of the allocation of managerial, financial, and technological resources necessary to implement an integrated EDI system (Iacovou et al. 1995).

- H9a: Managers' recognition of EDI benefits will be positively related to EDI's internal integration.
- H9b: Managers' recognition of EDI benefits will be positively related to EDI's external integration.

3.1.8 Obtained EDI benefits

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 et al. 1991). Higher potential rewards can be obtained by firms designing and implementing strategic applications (such as EDI) with an orientation both internal and external. It can be expected that organizations that integrate their internal functions with the functions of trading partners through EDI links will obtain greater benefits.

- H10: The obtained benefits will be positively related to the extend of its internal and external integration of EDI.

Organizations upon which the use of EDI was imposed do not integrate EDI into their organizational strategy. The organizations are not been committed with the project, and show an indifference for obtaining benefits or advantages, because they have not recognized the need for it.

- H11: Organizations upon which EDI is imposed obtain less benefits than those for which EDI implementation is voluntary.

3.1.9 Standardization

Mukhopadhyay et al. (1995) argue that organizations need to move toward higher levels of standardization to be able to reap the benefits of EDI. They also point out that EDI provides significant opportunities for process simplification and redesign. The benefits from EDI deployment are marginal if only superimposed on existing organizational conditions. The organizations can achieve to synchronize manufacturing, mitigate negative impacts of process uncertainties, facilitate reductions of inventory, and improve product and service quality by EDI links and its integration with internal systems.

- H12: Standardization in business practices and transactions will be positive related to the extend of its internal and external integration of EDI.

3.1.10 Relationships

Dependence is defined as the degree to which an organization needs external resources in order to achieve its own objectives (Reekers et al. 1995). The use of EDI

can lead to either reduced or increased dependence on trading partners. Reduced dependence can result from improved access to a range of strategic resources from other organizations. However, EDI can also increase an organization's dependence on others, for example, if EDI leads to higher coordination between customers and suppliers, or if the organization outsources some functions or processes to their suppliers. This increased dependence provokes long term contracts or stable business partnerships, but a reduction in the number of suppliers. The organizations which extensively integrate EDI with their internal systems will have the capacity to respond faster to customer requirements implying an improvement in customer service, and consequently, in an increase of its dependency.

H13: The level of interorganizational dependence will be positive related to the extend of its internal and external integration of EDI.

3.1.11 Markets

Organizations which are capable of effectively operating through EDI are likely to obtain preferential treatment from their partners. This will lead to a change in market structure with a rationalized supply base, changed basis of competition, and higher entry barriers. Some evidence for this landscape has been found in auto and retail industries. However, other industries have intentionally restricted the use of EDI (for example, insurance industry). Therefore, organizations use EDI links to influence both directly and indirectly on market structure and actors.

H14: The firm's influence on its market structure will be positive related to the extend of its internal and external integration of EDI.

4. Conclusions

In summary, the model unifies the research about IS implementation and EDI-specific research. The model comprised concepts, variables and measures derived from the theoretical and empirical approaches. The application of this model is likely to be useful to study the determinants and outcomes of EDI integration. Twenty-two propositions have been established to show the applicability of the model.

A great care has be taken in selecting appropriate quantitative measures from considerable number available. It is crucial that the chosen measures satisfy criteria of measurability, verifiability and validity. Similarly, great care needs to be taken regarding the qualitative evaluation, especially for critical aspects which are not directly measurable.

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