Factors influencing the implementation of electronic data interchange (EDI)

Abu Bakar Abd. Hamid
m-abakar@utm.my

Melati Ahmad Anuar
melati_jasmine@hotmail.com
Faculty of Management and Human Resource Development
Universiti Teknologi Malaysia

Gengeswari K.
k_gengeswari@intimal.edu.my
Faculty of Business and Accountancy
INTI International University College, Nilai

Abstract

Electronic Data Interchange (EDI) implementation is viewed as an important tool for transmission of business data. Yet, its implementation has not reached the predicted level whereby the implementation is often stalled at infancy stage. Many factors were pinpointed as inhibitors or barriers for success of EDI implementation. This study examines key EDI influencing factors and their relationship with implementation level, firm size and type of users. Mail surveys on 108 manufacturers were the main data collection method. Findings indicate that implementation level differs based on influencing factors, while these factors differ based on type of users and do not differ based on firm size. Relatively, internal factors were found to be more significant than external factors. This study also recommends future research to further examine influences of users' type with different EDI aspects.

Key words: *Information technology, electronic data interchange, small and medium enterprises, and business applications*

Introduction

Asian countries are witnessing rapid economic growth. The development of many Asian countries has in fact been characterized by rapid Asian industrialization and expansion of their export markets. One of the trends which have clearly emerged among some Asian countries is the use of Electronic Data Interchange (EDI) for their economic growth (UNESCAP 1996). They have taken the first step in setting up national networks that are targeted to improve the efficiency of business transactions through the handling of trade documentation electronically. Most of these countries have targeted their first EDI applications in the area of international trade. EDI has been claimed as vital for successful international trade as such activities require bundle of data exchanges between many parties across geographical boundaries; and the advent of EDI has facilitated these activities.

EDI is often attributed as the electronic transmission of business data from one computer to another computer system based on a structured format (Emmelhainz, 1994). Yet, the definition of EDI should be amended by replacing the term 'computer-to-computer' with 'application-to-application' as users could merely enjoy greater benefits when they have fully integrated EDI with other business applications (Mackay and Rosier, 1996; Parsa and Popa, 2003). EDI is used for transactions between and within organizations such as monitoring inventory levels, accessing marketing data (e.g. sales figures), placing orders directly with manufacturers and controlling inventory level. EDI is also used to perform traditional business to business (B2B) communication processes such as ordering, invoicing and providing shipping or backorder notification.

Past literatures have reported that EDI could yield enormous benefits provided that it is highly integrated. These benefits can be simplified as operational and strategic benefits (Elbaz, 1998; Mukopadhyay and Kekre, 2002; Parsa and Popa, 2003; Ngai and Gunasekaran, 2004). Operationally, EDI provides direct benefits such as reduction in costs associated with clerical labours and forms as well as in length of data transmission and processing. Further, an integrated EDI with existing systems is believed to facilitate the reengineering of some critical business processes including improvement in customer service and trading partner relationship and also as entry barriers for new comers and exit barriers for trading partners. Despite substantial potential benefits of EDI, the growth of EDI implementation has still been much slower than anticipated. For example, in America, a giant corporate nation, merely less than 5% of businesses exchange their trade documents electronically (Kalakota and Whinston, 1996 in Lu and Hwang, 2001). Significant initial investment or lack of financial resources was found to be the major inhibitor for EDI implementation (Chau, 2001; Parsa and Popa, 2003; Ngai and Gunasekaran, 2004). EDI implementation in fact entails high cost for communication network i.e. value-added network (Lummus and Duclos, 1995; Emmelhainz, 1994). Yet, recently, EDI cost has notably decreased due to the introduction of web-based EDI technology which is intended to enable trading partners to exchange EDI messages through internet. It was estimated that the average cost for exchanging 1000 messages via traditional EDI is about USD$650 per month while with Web-based EDI, the estimated cost can be reduced up to 50% (Lu and Hwang, 2001). With the Internet, more small to medium sized businesses are expected to implement EDI in exchanging information electronically within and between organizations. Besides high entrance costs, few other factors particularly lack of top management support, less EDI-capable trading partners and poor knowledge on EDI were found to be significant inhibitors (Iacovou et al., 1995; Bergeron and Raymond, 1997; Elbaz, 1998).

In fact, all these inhibitors are definite determinants of success EDI implementation as adequacy of these inhibitors would facilitate the implementation process. Thus, recognizing the influencing factors is vital and is the first step for successful EDI implementation. It has been acknowledged that there are considerable studies on EDI determinants from developed nations, yet it should be noted that these models or findings are not necessarily appropriate for developing nations. In past studies, large organizations and small and medium enterprises (SMEs) were separately examined. Many past studies have examined EDI implementation in general without considering users who were mandated to implement EDI where these users are seen to have different perceptions towards EDI compared to self-initiated users. Thus, this study is expected to fill these gaps determining the factors that influence EDI implementation among manufacturing companies in addition to examine differences in influencing factors based on firm size and type of EDI users.

Research model and hypotheses

A fundamental approach for the adoption of new technologies is the Roger's theory of innovation diffusion, which has been a foundation for many EDI research (Jimenez-Martinez and Polo-Redondo, 2004; Sunyeen, 2000; Iacovou et al., 1995). Rogers identified five factors i.e. relative advantage, compatibility, complexity, trialability and observability where the perceived characteristics of the innovation either encourage or inhibit a technology adoption. In case of EDI, relative advantage and compatibility were found to be positive determinants of its adoption (Sunyeen, 2000; Iacovou et al., 1995; Premkumar et al., 1994) while the system complexity was found to be the major hindrance (Ngai and Gunasekaran, 2004; Chau, 2001; Elbaz, 1998). Technology Acceptance Model (TAM) suggests that technologies acceptance is determined by the perceived usefulness and ease of use (Davis, 1989). Past literatures found a significant relationship with perceived usefulness and ease of use on the system acceptance or usage (Behrens et al., 2005; Money, 2004; Lederer et al., 2000; Teo et al., 1999). TAM can be also generalized to EDI, for instance, improved information accuracy (perceived usefulness) and absence of necessity for re-keying similar data (ease-of-use), which could facilitate the implementation of EDI.

EDI adoption determinants can be categorized into three major streams based on different theoretical paradigms taking different assumption (Vlachos, 2002). EDI adoption can be viewed as an innovation adoption; as a collaboration tool; and viewed from organizational behavior perspective. Paradigm of innovation adoption assumes that adopting organizations perceive EDI as an external innovation developed by a third party. Thus, as suggested by Roger's diffusion of innovation theory, EDI technical attributes such as relative advantage, compatibility and complexity determine its adoption process. Nonetheless, EDI implementation should also be viewed from the managerial and business rather than technical terms where EDI community has claimed that "EDI is 90% business and just 10% technology" (Swatman and Swatman, 1992; Emmelhainz, 1994; Chan and Swatman, 1998). This is because EDI is not merely another telecommunication advances but rather a tool to enhance cooperation within and between organizations. Consistently, the paradigm of organizational behavior assumes that certain aspects or characteristics of the adopting organizations considerably influence EDI adoption process. Top management support and adequate financial resources were found to be key facilitators for the adoption of any technologies including EDI. This theory explains why a large organization is likely to adopt EDI compared to a SME but it is hard to derive similar conclusive results for the majority of organizational characteristics. EDI in nature is a cooperative system where it requires at least two parties to commit the transactions. Thus, as claimed by paradigm of critical mass, EDI adoption depends on the collaboration among potential adopters. This theory argues that decisions on EDI adoption are influenced by a number of EDI-capable trading partners and trading partners' EDI integration level.

As EDI is a vital information technology (IT) tool, this study reviews IT literatures in addition to EDI literatures to reveal the literal EDI influencing factors. Table 1 summarizes the findings on influencing factors from past empirical literatures.

Table 1: Key influencing factors

No.	Authors	Year	Major Findings
1	Aguila-Obra & Padilla-Melendez	2006	Technological resources and managerial capabilities
2	Seyal & Rahim	2006	Government support and management support
3	Ngai & Gunasekaran	2004	Top management support, technical infrastructure and pressures from government
4	Brandyberry	2003	External communication and bureaucratic control
5	Leng Ang *et al.*	2003	Financial resources, requirement by government and technology compatibility
6	Zhu *et al.*	2002	Technology competence, users' readiness and competitive pressures
7	Chau & Jim	2002	Government support, perceived benefits and trading partners' influence
8	Kuan & Chau	2001	Imposition by government and top management support
9	Angeles *et al.*	1998	Trading partners' support, top management support and security controls
10	Mitropoulos & Tatum	2000	External requirements, competitive advantage
11	Heck & Ribbers	1999	External pressures and perceived benefits
12	Bergeron & Raymond	1997	Organizational support
13	Iacovou *et al.*	1995	External pressures and top management support

Based on the extent of literature on EDI adoption, a research model was built (Figure 1). This model comprises three major aspects i.e. EDI influencing factors, implementation level and demographic aspects. EDI implementation refers to the extent which EDI is being executed within organization and between trading partners. According to Emmelhainz (1994) there are three levels of EDI implementation i.e. level 1 (poor), level 2 (moderate) and level 3 (high). High implementation refers to comprehensive EDI integration with other systems where EDI yields enormous benefits and reengineers the way of doing business. Meanwhile, poor implementation takes place when EDI is used for limited transactions with high level of manual intervention, and at this stage EDI could yield merely minimal benefits. There are two groups of EDI users, i.e. mandated and self-initiated users. Mandated users refer to organizations that were imposed to adopt EDI, while self-initiated users refer to organizations that adopt EDI with their own initiatives and willingness. This study determines firm size based on the number of full-time employees (FTE). There are two groups of organizations, i.e. large organizations with more than 150 FTE, and SMEs with less than 150 FTE.

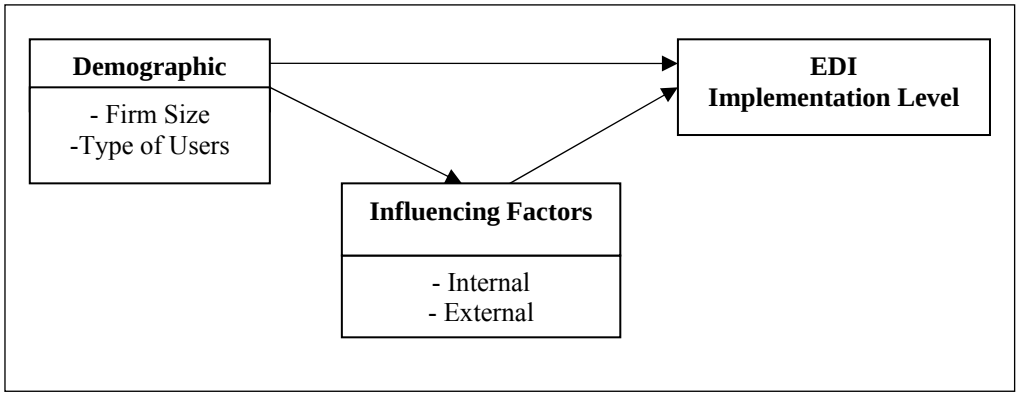

Figure 1: Research model

This study categorizes EDI influencing factors into two, i.e. internal and external. Internal factors refer to organizational and technological aspects which resulted from within organization and associated with the system itself. Internal factors comprise four major aspects, i.e. financial resources, top management support, technological availability and financial resources. Financial resources are very significant for successful implementation of EDI as such implementation entails substantial investment particularly at the initial stage. As EDI is believed to bring significant changes in business operation and entails significant investment, top management support considerably influences an organization's decision to adopt and integrate EDI. In terms of technological aspects, organizations might hesitate to adopt EDI especially the in-house system when they are lacking in terms of internal technical persons as outsourcing would cost high. Moreover, incompatibility with other existing systems and complexity in using this system might also slow down the adoption rate. Personnel acceptance towards implementation of EDI is also an important factor. Their resistance to change from using conventional methods would delay the implementation, thus they need to be educated and trained in advance. Adequate education and training would enhance personnel understanding and knowledge on EDI which will reduce their resistance level. External factors refer to influences or pressures from outside organization towards the decision to implement EDI. External factors comprise three major aspects, i.e. imposition or support by government, influences from competitors and requirement by larger trading partners. In most developing countries, EDI was initiated for facilitating international trade in general and for customs declarations in particular. Governments of these countries have made compulsory customs declarations via EDI for companies that engage in international trade. Thus, majority of companies especially SMEs have implemented EDI due to the imposition without their own willingness. Requirements by larger trading partners to implement EDI considerably influences decision to adopt EDI. In order to maintain a good relationship and hence businesses with trading partners, users have to adopt EDI. In addition, influences from competitors would insist users to adopt EDI as they do not want lagging behind especially in reaping enormous benefits of EDI.

With reference to the research model in Figure 1, the following hypotheses were proposed.

$H_{01:}$ There is no difference in EDI implementation level by type of users.
$H_{02:}$ There is no difference in EDI implementation level by firm size.
$H_{03:}$ There is no difference in EDI implementation level by influencing factors.
$H_{04:}$ There is no difference in influences from internal factors by type of users.

$H_{05:}$ There is no difference in influences from external factors by type of users.
$H_{06:}$ There is no difference in influences from internal factors by firm size.
$H_{07:}$ There is no difference in influences from external factors by firm size.

Research methodology

As a target population for this study, a total of 1200 manufacturers (SMEs and large organizations; mandated users and self-initiated users) was drawn from Malaysian Manufacturers Portal and Directory (http://www.e-directory.com.my/). From the 1200 manufacturers, 300 were randomly chosen. The questionnaire was distributed to the chosen manufacturers and six rounds of follow-up were executed via e-mail to ensure the substantial return rate. However, only 108 completed questionnaires were returned. The collected questionnaires were analyzed using the Statistical Package for Social Science (SPSS) to produce more reliable results.

Influencing factors were measured based on five-point Likert scale (1=strongly disagree and 5=strongly agree); this study emulates Bergeron and Raymond (1997) for influencing factors. Level of integration was measured based on ordinal scale (1=poor and 3=high); this study emulates Emmelhainz (1994) for EDI implementation level. Type of users and firm size were measured based on nominal scale.

Reliability and validity tests were performed on the data collected. Construct reliability was assessed by computing Cronbach's alpha where items used for the analysis showed an adequate level of reliability with their alphas amounting to 0.95. Content validity was enhanced by using the measures already validated in previous studies and by conducting the pilot test among potential respondents and university lecturers. Convergent analysis test was performed using the principal component factor analysis on items that measured EDI influencing factors. All items had factor loading values greater than 0.7, thus items which had factor value lower than 0.5 were excluded from further analysis in order to ensure the construct validity (Seya and Rahim, 2006).

Findings and discussions

Respondents of this study comprise 76.9% of mandated users and 23.1% of self-initiated users. Of 108 respondents, 64.8% of them are large organizations and 35.2% are SMEs. Meanwhile, only 8.3% of respondents implement EDI at high level, while 92% implement EDI at poor and average level (see Table 2). Chi-square test was performed on the type of users and firm size. Pearson Chi-square value of 1.703 with high p-value of 0.192 signal that there is no relationship between type of users and firm size. This finding is in contrast with findings of past literatures that claimed firms which were imposed to implement EDI are likely to be SMEs as they have inadequate resources (Seya and Rahim, 2006; Fillis et al., 2004; Parker and Swatman, 1997).

Table 2: Frequency Analysis

Category	n = 108	%
Types of EDI users		
Mandated	83	76.9
Self - initiated	25	23.1
Firm Size		
Small and medium	38	35.2
Large	70	64.8
Level of EDI implementation		
Poor	74	68.5
Moderate	25	23.2
High	9	8.30

Null hypotheses 1 (H_{01}) and 2 (H_{02})

Mann-Whitney *U* tests were employed to examine the differences in level of EDI implementation by type of users and firm size (Table 3). For type of users, as mean rank for self-initiated users (88.73) is significantly higher than the mean rank for mandated users (45.21), it indicated that self-initiated users implement higher level of EDI than self-initiated users. Low p-value=0.000 indicates that there is a significant difference in level of EDI implementation by type of users; thus, **H_{01} was rejected**. It can be concluded that self-initiated users implement EDI significantly higher than mandated users. Inherently, users who were mandated to implement EDI are likely to reluctant to further integrate EDI as they might not have sufficient resources or could not quantify actual EDI benefits (Elbaz, 1998; Leng Ang et al., 2001; Parsa and Popa, 2003). Meanwhile, high p-value=0.536 indicates that level of EDI implementation is similar for SMEs and large organizations; thus, **H_{01} was not rejected**. This finding is in contrast with findings of past literatures that claimed large organizations tend to further integrate EDI than SMEs as they have adequate financial and technological resources (Zhu et al., 2002; Chau, 2001).

Table 3: Mann-Whitney U Tests

Variables	n = 108	Mean Rank	p	Z
Type of Users				
Mandated	83	45.21		
Self-initiated	25	88.73	0.000	-7.431
Firm Size				
Small and medium	38	57.58		
Large	70	54.36	0.536	-0.619

Null hypotheses 3 (H_{03})

Table 4 lists EDI influencing factors with mean and standard deviation (sd) value based on descending order. Top management support, financial resources and imposition by

government were found to be the most significant factors for EDI implementation. These findings are consistent with findings of many past studies, e.g. Seya and Rahim (2006), top management support; Leng Ang *et al.* (2003), financial resources; and Ngai and Gunasekaran (2004), imposition by government. Meanwhile, personnel acceptance and trainings or education for personnel were found to be least significant factors that influence EDI implementation. This finding is in contrast with findings of several past literatures which claimed personnel acceptance and EDI training or education (Arunachalam, 1995; Parker and Swatman, 1997; Jun and Chai, 2003) are important in order to ensure successful EDI implementation. As there were more mandated users, they might just obey the instructions and thus implement EDI without considering personnel acceptance. Logically, personnel resist because of the discomfort of using new technologies or they are afraid that EDI would replace them. At this stage, education and training prior to and during implementation are very significant as these can enhance personnel understanding towards EDI and will help increase acceptance rate. Means were again computed on the overall internal factors and external factors. Internal factors (mean=3.48) were found to be most significant influencing factors than external factors (mean=3.22). In order to examine the differences in EDI implementation level based on influencing factors, Kruskal-Wallis test was performed. Findings ($\chi 2$=9.817 and p-value=0.007) indicate that EDI implementation level differs based on influences from EDI influencing factors; thus, **H_{03} was rejected.** Previous studies found that internal factors positively influence decision to adopt EDI while external factors negatively influence decision to adopt EDI (Iacovou et al., 1995; Elbaz, 1998). Thus, all influencing factors should be taken care as improper management or inadequacy of these factors would impact the level of EDI implementation which is positively related with extent of received benefits (Emmelhainz, 1994; Parsa and Popa, 2003).

Table 4: Means of EDI influencing factors

Factors	Mean	sd
Top management support	4.45	0.51
Financial resources	4.05	0.94
Imposition by government	3.80	0.83
Internal technical persons	3.40	0.94
Compatibility with existing systems	3.35	1.04
Requirements from trading partners	3.25	0.91
Influences from competitors	3.25	0.72
Ease of use EDI	3.05	0.76
Personnel acceptance	2.80	1.40
Trainings and educations for personnel	2.60	1.35

Null hypotheses 4 (H_{04}) and 5 (H_{05})

Independent sample t-tests were employed on influencing factors and type of users in order to examine the differences in influencing factors based on the latter variable. Results indicate that both internal factors (p-value=0.033) and external factors (p-value=0.001) were found to vary based on type of users; thus, **H_{04} and H_{05} were rejected.** In order to determine the most significant factors for each group of users, mean comparisons were computed (Table 5). Results indicate that, relatively, internal factors were found to be most significant factors for both mandated users (mean=3.71) and self-initiated users (mean=3.29) than external factors. As there were more mandated users, it is expected that external factors would be the most influencing factors yet the findings (Table 5) are in contrast with the presumptions.

Table 5: Mean Comparisons

Type of Users	Value	Internal Factors	External Factors
Mandated	Mean	3.71	3.56
	sd	0.25	0.44
Self-initiated	Mean	3.29	2.94
	sd	0.51	0.29

Null hypotheses 6 (H_{06}) and 7 (H_{07})

Independent sample t-tests were employed on influencing factors and firm size. Results indicate that both internal factors (p-value=0.122) and external factors (p-value=0.657) were found to be similar for both SMEs and large organizations; thus, **H_{05} and H_{06} were accepted.** This signals that respondents of this study receive similar extent of influences from external and internal factors despite their firm size. The analysis was furthered with means comparisons in order to determine the most significant factors for each group of users (Table 6). Results indicate that, relatively, internal factors were found to be most significant factors for both SMEs (mean=3.86) and self-initiated users (mean=3.33) than external factors.

Table 6: Mean Comparisons

Firm Size	Value	Internal Factors	External Factors
Small and medium	Mean	3.86	3.33
	sd	0.12	0.25
Large	Mean	3.41	3.20
	sd	0.47	0.51

Conclusions and recommendations

In conclusion, there were more mandated users (76.4%) where 91.8% of the respondents implement EDI at poor and average level. As suggested by previous researchers, these users probably would not receive enhanced benefits from EDI due to poor implementation and thus ultimately they would stall EDI implementation at infancy stage without further integration. However, the findings have failed to prove that there is a difference in EDI implementation level between SMEs and large organizations. Top management support, financial resources and imposition by government were found to be the most significant factors. Furthermore, findings have indicated that influencing factors have significant impacts on EDI implementation level. These factors were also found to vary based on the type of users but were similar for both SMEs and large organizations. Relatively, internal factors were found to be the most influencing factors than external factors. Thus, it can be concluded that although there is imposition from external factors, organizations will only implement EDI if they have sufficient internal sources as they are afraid that inadequacy of internal sources might be harmful and ultimately may be inhibitors for the entire EDI implementation process. Clearly, the findings of this study cannot be generalized as this study was conducted on manufacturers located in three states instead of all users from different economic sectors throughout Malaysia. Further, the sample size was also inadequate to generalize the findings. However, this study is expected to contribute to the EDI or IT literatures as well as being a starting point for further investigations. This study has demonstrated that the type of EDI users has significant impact towards EDI implementation, thus this study recommends for future

research to further examine the impacts of EDI users' type with different EDI scope and to examine implications of EDI implementation and their relationship with EDI implementation level. Research should also be conducted across different economic sectors nationwide. Further, both quantitative and qualitative methods are suggested to produce comprehensive findings. A longitudinal study should be employed to track the changes in EDI implementation process as well as users' perceptions and acceptance towards EDI over time.

EDI community consisting of Government, EDI vendors and users should be aware of variety of issues facing mandated and self-initiated users. Government should change the way of encouraging users to implement EDI instead of making such implementation as compulsory. For example, monetary rewards or privileges should be given to the first 100 users who implement EDI within a given duration. Furthermore, government should not stall this imposition or encouragement just with customs declarations instead more government related activities should be involved. With diversity of EDI applications, users are likely to implement EDI at a greater rate. This study found that education or training is the least significant factor that influence EDI implementation. This signals respondents lack EDI-associated education or training. Thus, EDI vendors should frequently conduct demonstrations, training and workshops on EDI implementation in order to help users to understand better EDI implementation process and its implications. Finally, users must play their roles in order to benefit from EDI implementation. Users should change their mindset and accept new technologies in facilitating their business transactions (Straits Shipper, 1995). Users should understand imposition by government will benefit them. Although they were initially mandated they should gradually integrate EDI with existing systems in order to enjoy enormous EDI benefits. Users could also collaborate with their suppliers and customers to help each other on EDI associated activities.

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