EDI 통제가 EDI 성과에 미치는 영향: 구조방정식 모형

이상재*, 한인구**

The impact of EDI Controls on EDI Performance: A Structural Equation Model

Sangjae Lee, Ingoo Han

Abstract

This paper examines the effects of formal, informal, and automated controls on EDI performance. Hypotheses indicate that controls directly and indirectly affect performance through their effect on implementation success. A structural equation modeling approach (LISREL) is used to analyze data from Korean companies.

Formal controls turn out to be the most important as they directly and indirectly affect performance. Informal controls have only an indirect effect on performance, while automated controls affect performance only directly. The results empirically support that there exist causal relations among EDI controls, implementation success, and performance.

*한국과학기술원 테크노경영연구소 연구원, ** 한국과학기술원 테크노경영대학원 교수

1. Introduction

EDI can be defined as the interorganizational exchange of business data in a standard format via telecommunication network. The empirical literature on the consequences of EDI shows general support for their benefits: the reduction of enhanced speed and accuracy of communication, order-processing and inventory costs, elimination of labor-intensive tasks, and increase market share (e.g., Kumar and Cook, 1996). The continuously accelerated rate of EDI proliferation in recent years has prompted a growing number of researchers to investigate some of emerging issues surrounding the adoption and implementation of EDI. Although the reported benefits of EDI have generally fulfilled expectation, there exists a need to explain why beneficial consequences result. One of the factors that affect a successful EDI implementation is EDI controls for the system security and integrity (Hansen and Hill, 1989; Banerjee and Golhar, 1994).

The integration with IS application and high transaction volume are necessary for EDI to be successful (Benjamin et al. 1989, Horan 1988, Iacovou et al. 1995, Stern and Kaufmann 1985, Teo et al. 1995). When EDI is utilized and automated to the full extent, the advantages from EDI can increase (Scala and McGrath 1993). However, the risks of domino effect resulting from errors, omissions, and failures greatly increase when information system applications such as order processing are integrated with other business applications. The errors and failures of one system rapidly propagate into other systems because of the high speed and the lack of human intervention in this integrated system. The high costs and high degree of automation associated with EDI systems increases the risk of potential loss resulted from inappropriate planning and control maintenance (Lee et al. 1998).

The competitive advantage from EDI can be derived only if the integrity and accuracy of data are controlled. Deliberate or erroneous loss of data during data communication can wipe out the savings of administrative and operating cost. Cost-effectiveness of controls can be ensured when the state of implementation becomes higher. The effectiveness of controls depends on the extent of implementation. Before an organization decides to implement EDI, the controls for EDI need to be planned in order to give a belief that system is safe and accurate to users or increase the capability of implementation and adjustment. EDI controls can also improve the relationship with trading partners and the productivity including cycle time reduction and the data accuracy.

EDI controls ensure that an organization achieves its goals through implementation of EDI. Controls of IS are the activities to safeguard assets, maintain data integrity, accomplish organizational goals effectively, and consume resources efficiently (Weber 1988). If companies make decisions based on incorrect data, they confront serious risks. The risks might be caused by deliberate computer abuse or by a disruption of processing due to natural disaster. Inaccurate data may bring about invalid issuance of orders or bills.

Most studies on IS controls focus their attention on the impact of deterrents or preventives on reducing computer abuse. The dependent variable is either incident rate of abuse and costs incurred from abuse (Straub, 1992) or individual security-related behavior (Frank et al., 1991). This paper examines the direct and indirect effects of formal, informal, and automated EDI controls on the system performance. The hypotheses on indirect effects of EDI controls on performance through implementation success

are discussed. A structural equation modeling approach (LISREL) is used to test instruments validation and the research model. One of main purpose of the study is to provide a clear definitions of constructs, operationalizations, and the functional relationships between constructs using a structural equation modeling approach. A summary of empirical findings is provided in the end.

2. Theoretical Framework for Control Mechanisms

2.1 IS Controls, IS Implementation, and Performance

Much research have been performed to better understand various factors that affect IS implementation success (Cooper and Zmud, 1990; Desanctis and Courtney, 1983; Ives and Olson, 1984; Premkumar et al., 1994; Sanders and Courtney, 1985). However, the studies on the role of IS controls in IS implementation are quite limited. The stage model of IS suggests that IS controls are increasingly important as IS installation passes through various stages within an organization (Cooper and Zmud, 1990, Nolan, 1973, 1979). From a control viewpoint, the turning points in Nolan's S-shaped IS maturization curve indicate the critical time to emphasize controls (Weber, 1988). More organizational controls and procedures are needed to manage innovation and the new work environment are required as the use of new IT increases. The computer security specialists need to participate in the decision to authorize new IS applications before system design begins (Parker, 1981).

Adequate controls must be in place to provide "control assurance" to stakeholders such as internal users, trading partners, and industry association, in terms of contractual obligations or agreements, before the decisions regarding further implementation of system can be made (Chan et al., 1993). Some internal applications planned for computerization might have to be done manually if sufficient security is not provided in computer use (Parker, 1981). Reduction of risk is likely if the candidate tasks to be computerized is safely done manually. In case of IOS, companies are called upon to establish "adequate" level of controls, specified in trading partner agreements, by their trading partners, especially influential ones, before connecting their system to trading partners' systems (Jamieson, 1994; Mehta, 1998). For example, if the retailer is sharing its information with the manufacturer through IOS, this allows shared computing environment and marketing and manufacturing decisions. The manufacturers have the contractual agreements with their retailers about, for instance, fail safe bar coding practices, logistics systems.

Organizational and IS controls have been related to organizational or IS performance. Controls in marking units are related to job satisfaction of employees, person- role conflict (i.e., "the extent to which role expectations are incongruent with the role orientation of the role occupant"), role ambiguity, job performance of marketing managers (Jaworski et al., 1993). IS development team controls are related to team performance such as efficiency, effectiveness, and elapsed time (Henderson and Lee, 1992) and help accomplish a set of goals, which may include timeliness of implementation, a quality of end product, client satisfaction, and reasonable project costs (Kirsch, 1996). For instance, outcome controls (e.g., standards, project plan, requirements documents, system testing) are used to ensure that the new systems met system standards (e.g., file layout, dataset naming conventions) and user requirements and implemented on-time and within budget. One type of computer abuse, software piracy is negatively affected by the use of security measures (e.g., Im and Epps, 1992). Preventive (e.g., nonstandard disks, hardware locks) and deterrent controls (e.g., educational campaigns, promotion of copyright laws) against software piracy reduce piracy rate and the latter has a positive impact on software publisher profits (Gopal and Sanders, 1997).

IS security and integrity controls are also related to IS performance for several reasons. First, organization cost from data loss or invalid data from accidental acts can be reduced from using appropriate controls (Weber, 1988). Incorrect and unreasonable transactions from accidental omission or duplication of data, may badly affect transaction cycle and lead to invalid issuance of invoice or production order and, ultimately, a loss of credit and image as well as market share and competitive advantage of organization. The success of protection can be accurately measured from incidence statistics and the appropriate controls can be established on the basis of the need that is determined (Parker, 1981). It is possible to draw advantages from IS only if the integrity of IS is ensured for the productivity and effectiveness of business.

Second, computer abuse, any illegal activities to use IS resources for personal purpose, can be prevented establishing appropriate IS controls. Although expected loss from intentional acts such as fraud, theft, embezzlement, piracy is difficult to be determined, these computer abuses cause severe losses to organizations and the methods of computer abuse become diverse as the IS sophistication increases and users are becoming more adept at committing various types of computer abuse (Straub and Nance, 1990). Vigorous enforcement of deterrent (e.g., distributed policy statements, computer security awareness education) and preventive controls (e.g., access control software, automated input controls) will lower future computer abuse (Straub, 1992). The psychological trait of denial of responsibility also affects the intention of computer abuse; security measures that focus on aspects of responsibility, such as employee morale monitoring, clear job description and placement practices are important to prevent computer abuse (Harrington, 1996). Company profits can increase using deterrent antipiracy measures for software piracy, one type of computer abuse (Gopal and Sanders, 1997). Formal policies and perceived personal responsibility, informal norms affect security-related behaviors of PC users, and authorized use of IS resources, which becomes critical as PC applications become more pervasive and important throughout managerial tasks (Frank et al., 1991). Hence IS controls contribute to IS performance by reducing computer abuses.

Third, the quality of decision making can be improved through accurate and reliable data and decision rules (Weber, 1988). The quality of management controls is critical to the formation of strategy and competitive positions of organization, as management controls exists not only to monitor that outcomes conform to plans but also to provide insight concerning the current and expected state of strategic uncertainties (Simons, 1990). The accurate information is needed for decision regarding planning, performance reporting, environment scanning, budgeting, competitor analyses, and resource allocation. Inaccurate data may cause inappropriate allocation of budgets, and out-of-control processes undetected, which may result in substantial loss of productivity competitive advantage.

Fourth, as the greater extent of IS controls leads to the higher potential for EDI implementation which is related to IS performance, IS controls affect performance indirectly through their effect on IS implementation. The IS security and integrity controls becomes critical as the growth of

connectivity and dispersion of technology within or between organizations continue (Boockholdt, 1989; Loch et al., 1992). Although the errors and losses due to unintentional or intentional act and the expected reduction of these incidents from implementing controls is difficult to be determined (Rainer et al., 1991), IS controls have still benefits, as they are related to the extent of IS implementation success which affects IS performance.

2.2 Three Modes of EDI Controls

The purpose of EDI controls is to ensure that an organization accomplishes its goals through the implementation of EDI. In this study, EDI controls are defined as the activities or process to safeguard assets and maintain data integrity. These controls focus on system development, modification, maintenance processes, and management of data and processing. EDI controls lowers the risk of unauthorized and inadvertent destruction or removal of assets ensuring data is authorized, accurate, and complete. Controllers structure a portfolio of control modes in order to manage the complexities and subtleties of a task that involves people with various knowledge and skills. Many other ways in which EDI controls might be exercised exist but this study focuses on three modes of controls; formal, informal, and automated controls.

Formal EDI controls are "written management-initiated" controls and are based on written procedures. Formal mechanisms include rules, regulations, and hierarchy of authority to ensure the security and integrity of EDI, and are used to direct the behavior and assess performance. For instance, formalized procedures of maintaining user password, change control procedures for access control software are formal controls (e.g., Mehta, 1998). Informal controls are based on the beliefs and values shared by members of an organization. Informal EDI controls are initiated by organization members using the members' values, judgments, and communications. Informal controls have the following components; risk recognition, sense of responsibility, experience, and interaction among the members of the EDI staff. The examples of informal controls include experience, user recognition of responsibility and faithfulness to the procedures in order to increase the effectiveness of the control system (e.g., Frank et al., 1991; Harrington, 1996). Automated EDI controls indicate automated control procedures and methods. They include programmed integrity check and security and authentication software (Powell, 1994). Automated access control software, and embedded audit routines are also necessary as the access process becomes routine and repetitive (Zoladz, 1994). Automated control can find out and correct invalid or unauthorized accesses more accurately than manual systems in standardized and automated processes.

Formal and automated controls can be categorized into *application* and *communication* controls. *Application* controls deal with internal components of EDI systems such as the application system while *communication* controls are involved with an external EDI systems like the interface with VAN or a network provided by trading partners such as a VAN or trading partner. As the strength of the control system varies from VAN to VAN, it is necessary to establish EDI adopters' own control procedures (Joseph et al., 1999).

3. Research Hypotheses

3.1 Formal Controls and EDI Performance

Total effects of formal controls on performance can be divided into direct and indirect effects through implementation success. The direct effect of formal controls indicates that formal controls affect performance regardless of the level of implementation success. It is meaningful to test this direct effect in comparison with indirect effect. Indirect effect is defined as the effect of a particular variable on the second variable through its effects on a third mediating variable. Indirect effect of formal controls on performance represents that formal controls affect performance through its effect on implementation, a mediating variable between formal controls and performance. This mediation perspective specifies the existence of a significant intervening mechanism (i.e., implementation) between an antecedent variable (i.e., formal controls) and the consequent variable (i.e., performance).

Customer service is improved with the avoidance of paper manipulation and data re-entry by recipient partner organization, and this improvement depends on the extent of usage of standardized procedures and data integrity controls of the communication process. The speed, accuracy, and completeness of partner communications are enhanced by standardizing and formalizing the communication process and procedures (Stern and Kaufmann 1985). The communications transport protocol (e.g., SDLC, ASC, BISYNC) indicate the method by which message is sent. Message format contains both the data itself as well as identification and routing details; interchange control segments indicate a set of documents transmitted between organizations at one time (Senn, 1992). The structured and routine processes enable the coordination of transmission between sending and receiving computers. increase the accuracy and speed of EDI process. Further, EDI will result in the amassing of more and more data available for analysis, and the quality (completeness, accuracy) of information available to linked distributors and vendors in a bargaining situation is very important to make highly satisfying (e.g., joint profit-maximizing) decisions (Stern and Kaufmann, 1985). Hence, formal controls that ensure data security and integrity directly affect performance.

Effective controls for EDI transactions are needed before they are transmitted in order to protect the other parties from the mishaps in their applications or after they are received in order to protect inner applications from the intentional or unintentional errors in the systems of other parties (Mehta, 1998). Further, if their organization (e.g., workflow) or technical processes (e.g., message, protocol) are not standardized, it is difficult to be linked with other EDI adopters. Security and control issues are the impediments to EDI implementation especially when third parties like service bureaus are involved (Stern and Kaufmann, 1985). EDI adopters need to select the VANs and their subscribers that can provide basic control functions and accept standard EDI transaction procedures (Joseph et al., 1999). EDI adopters are supposed to implement EDI further if its benefits exceed development costs, which are ensured through the usage of appropriate formal controls. Hence formal controls are prerequisite for EDI implementation success.

As the extent of implementation success is related to performance, formal controls can be associated indirectly with performance. The integration and expansion of networks can lead to the better customer service and improved inter-firm relationship as more rapid and accurate information can be provided to their partners. After EDI is utilized intensively being interacted with internal applications, electronic links are expanded and various types of EDI documents are developed. The economy of scale is possible from intensive use of EDI covering the initial large cost of installation. As formal controls affect implementation success that is associated with EDI performance, formal controls

affect performance indirectly through their effect on implementation success.

Hypothesis 1-1: Formal controls directly affect EDI performance.
Hypothesis 1-2: Formal controls indirectly affect EDI performance though implementation success.

3.2 Informal Controls and EDI Performance

The impact of Informal controls on performance can be also divided into direct and indirect. It is worthwhile to test the direct effects of informal controls as well as indirect effects of controls through implementation success. Security has resisted standardization efforts because so many types of assets, threats, and conditions of vulnerabilities exist (Parker, 1981). Assets, potential threats, and countermeasures (or controls) cannot be completely identified and established. In order to reduce risks to acceptable level from computer abuse, users as well as IS staff members assume responsibility for adequate security in the supplying of data and the use of IS resources (Frank et al., 1991; Harrington, 1996; Parker, 1981). If EDI staff members or users possess the sense of responsibility, the probability of abuse and errors may be reduced. The reliability and effectiveness of an EDI system relies on the integrity, competency, experience and ethic of EDI personnel (Aggarwal and Rezaee, 1994). The direct benefits derived from having commitment to EDI system operation and maintenance and risk recognition relate to the decreased occurrence of irregularities in EDI environments. The knowledge and experiences of EDI staffs are also important factors for the effective management of systems. These controls decrease the level of expected risks from unauthorized and inadvertent destruction of assets. So informal controls can directly affect performance.

The risk recognition, sense of responsibility, experiences, and interaction of EDI staffs are prerequisite to manage a complex network infrastructure which links different hardware/software and network protocols, and is integrated with the various internal application systems like production system or accounting system in conjunction with external network. Although the IS people are responsible for the implementation of EDI, the interaction among other functional groups is usually necessary before the EDI implementation projects are completed (Stern and Kaufmann, 1985). All of the various groups (e.g., technical or user groups) may cooperate with the counterparts of trading partners to implement the linkage. Further, it is not easy for EDI adopters to expand the connection unless if they don't have informal controls by organizational members. As transaction amounts, processing loads, and technical complexity increase, EDI staffs might increasingly recognize the inherent risks of systems. As trading partners demand more effective controls in the highly implemented environment of EDI, the experience and knowledge to control EDI become more required (Chan et al. 1993, Cafiero and Dearing 1989, Jamieson 1994). The knowledge and skills as well as risk recognition and responsibility in their work to manage the increased risk of the system become important as they further integrate and expand EDI system.

The extent of implementation success that is affected by the use of informal controls is positively associated with performance. The internal needs as well as the requirements of external partners should be satisfied to attain the EDI system objectives. This is possible from appropriate integration with these applications. The extensive utilization of EDI is required to reap its full benefits. A comprehensive usage of EDI can lead to high performance supporting higher-level aspects of organizational work and facilitate the widespread transfer of the technology to other application systems. As informal controls affect implementation success and the extent of implementation success is directly related to EDI performance, informal controls affect performance indirectly through their effect on implementation success.

Hypothesis 2-1: Informal controls directly affect EDI performance.
Hypothesis 2-2: Informal controls indirectly affect EDI performance though implementation success.

3.3 Automated Controls and EDI Performance

Direct and indirect effect of automated controls on performance may also constitute total effects of automated controls. Direct effect of automated controls on performance can be separately tested without consideration of their effect on implementation success. Preventive controls using automated detection and correction mechanism are more useful than after-the-fact exception reporting and corrective procedures. The reason is that they check the compliance with accepted standards and this detects errors before far reaching into other applications (Madsen, 1994). For instance, a shipping document may automatically generate transactions such as transportation requests, inventory adjustments, customs declaration, purchase orders, and invoices. A shipment order of wrong amount may result in a several-fold potential loss of revenue for one or more trading partners. It is much more prudent to perform preemptive sanity checking on both inbound and outbound EDI messages if there exists any indication of a problem (Benesko and Teplitzky, 1995). EDI's automated and real-time nature demands the function of EDI control systems to isolate and track individual EDI transactions from origin to destination (Benesko and Teplitzky, 1994). It is possible through automated controls (e.g., source document logging, internal tracking mechanisms) to ensure the same or better degree of accuracy as conventional paper-based business transactions.

The information about the severity of punishment and penalties can be clearly and accurately delivered to them while they are using programmed control system. This can affect motivational and environmental factors that are implicit, are equally effective to decrease computer abuse (Straub 1992). The timely identification and resolution of critical problems are possible. EDI system needs the embedded automated controls that detect and correct errors in order for EDI to function. If controls are automated, accuracy, timeliness, completeness, and recoverability of EDI transactions can increase. Hence, automated controls can be hypothesized to directly affect performance.

Automated controls are related not only to performance but also to the extent of implementation success. As the speed and volume of system processing increase, tracking and control mechanisms need to be installed for the continuity of EDI services (Chan et al. 1993, Jamieson 1994). When internal applications are integrated with external partners, communication controls need to change from being manually managed to being automatically managed (Zoladz, 1994). The errors in inbound transaction need to be detected early in the transaction processing cycle in order not to delay the response time. Trading partners would not connect with EDI system if it turns out that the system possesses security problems. If it fails to promptly detect and correct errors in

data right after it receives transactions, the effectiveness of their system might be significantly diminished (Mehta, 1998). It is hard to expect further implementation of EDI unless adequate automated controls are installed to manage the interface between application systems and EDI network (Aggarwal and Rezaee 1994; Marcella and Chan, 1993). Hence automated controls affect the level of implementation success.

The increase in the extent of implementation with the use of automated controls can also contribute to system performance. As they adjust their internal systems to permit interface with their trading partners, the implementation of EDI may demand significantly high one-time cost on organization. Electronic links and EDI transaction documents should be expanded in order to derive the full benefits from EDI as substantial cost effectiveness can be realized from using EDI with diverse partners. When the system of trading partners is integrated with customers, cycle time can be greatly reduced through the rapid transmission of data. As automated controls affect integration and utilization that are critical to shorten the response and turnaround time, automated controls indirectly affect performance through their effects on implementation success.

Hypothesis 3-1: Automated controls directly affect EDI performance.
Hypothesis 3-2: Automated controls indirectly affect EDI performance though implementation success.

4. Research Methods

4.1 Data Collection

Structured interviews were used as the main data collection method. Some questions about EDI controls may require sensitive information about security and data integrity. These questions can be better answered by the structured interview than by any other data collection method. Further, as all the items of controls are newly developed in this study, it is important to know whether these items can be appropriately answered by EDI practitioners. Interview provides the opportunity to aid the respondents in their interpretation of the questions, and allows the flexibility in determining the sequence and wording of the questions.

2000 companies were selected from publicly available company databases (through Chollian network service). Among these companies, respondent organizations were composed as follows. First, the industries, which have heavily used EDI, were identified. Questions about controls can be answered reliably only by the companies which have implemented EDI heavily. Second, from publicly available company databases, the companies in those industries which are likely to have implemented EDI comprehensively were contacted to check their level of EDI implementation. The respondents selected supposedly possessed the level of knowledge about EDI controls required to answer the questionnaire from the results of preliminary pilot test.

Eight companies refused to participate in the interview. All of remaining firms responded to the request for information and are included in the study. The response rate was 92 %. The response rate is high because the participation in the survey was solicited through a direct call to EDI managers and the objectives of the study explained. A comparative analysis of industry membership and revenues was conducted in order to see if responding firms have significantly different characteristics from nonrespondents. No significant differences were found supporting that response bias is not a concern in this study.

One or two EDI managers simultaneously participated in the interview. They were believed to have sufficient knowledge about EDI implementation. The disagreements among two managers were rare and most of the respondents modified their responses when they have different opinions on each question. If some questions could not be answered, they took those questions to their colleagues who had sufficient knowledge of the subject area.

The data used in validating the research model are gathered as part of a larger investigation concerning the EDI controls (see Lee et al. (1998)). The survey instrument was verified first by interviewing EDI practitioners from each firm. Wording, interpretation and importance of items, and the extent to which practitioners feel they possess the knowledge necessary to provide appropriate responses were analyzed until the last draft of the questionnaire, which required only minor a very limited number of minor revisions. Some items for controls were modified to indicate more straightforward meanings. Ten interviews with practitioners were conducted and a final review were made by four IS professors. A total of 110 usable responses were received from EDI staffs or managers. The unit of analysis is individual EDI adopting company.

4.2 Measures, Measurement Reliability, and Validity

The measurements for the controls are based on the studies of Lee et al. (1998). Items for EDI controls are refined based on EDI literature including Chan et al. (1993), Jamieson (1994), Marcella and Chan (1993), and ISACA (1990) (Table 1). They are measured using a seven point Likert-type scale. The measurement is based on the responding firm's perception of controls.

Insert Table 1

The measures for implementation success indicate the extent that the responding firm has implemented EDI and are based on the EDI literature (Massetti and Zmud, 1996; Premkumar et al., 1994; Premkumar and Ramamurthy, 1995) (Table 2). Integration is measured by the integration of five application systems which respondents believe to be closely connected with EDI. Integration is defined by the extent to which EDI data can be directly processed within applications without human intervention. The five tasks - some companies have less than 5 tasks - are believed to be most closely connected with EDI by respondents and can represent the characteristics of EDI applications of EDI adopters at the organizational level. The examples of applications are categorized as trade, retail, transportation and banking. Others applications include production, insurance engagement, and credit card usage recording.

The measure for utilization indicate the proportion that a company use EDI in the five applications which can be processed using other complementary means such as e-mail or fax. It is measured as the proportion to which a firm's information exchange and processing are handled through EDI.

Insert Table 2

The measures for EDI performance are based on various EDI survey results (Arunchalam 1995, Banerjee and Gohar 1994, Hansen and Hill 1989) and EDI management and controls (Chan et al. 1993, Emmelhainz 1990, Jamieson 1994, Marcella and Chan 1993, Senn, 1992). The measures of perceived EDI performance can be sought from the objectives of EDI usage. The reinforcement of ties with a

business partner, improved customer service, cost reduction and increased reliability of information are the most important benefits recognized by the majority of respondents in the pilot study. The measures for the implementation success and performance are summarized in Table 2. The measurement model is shown in Figure 1.

Insert Figure 1

The scales were subjected to a confirmatory factor analysis involving all of the measures. The data were generally consistent with the hypothesized measurement structure although chi-square was significant (chi-square = 50.785, d.f. = 25, $p < 0.01$). The fit indices are all indicative of good fit (GFI = 0.921, AGFI = 0.826, RMSR = 0.061). The measurement model with five concepts needs to be tested against data to establish its measurement properties. The test can be conducted through the assessment of reliability, content validity, and discriminate validity of measures.

Reliability and validity tests are conducted for each latent variable and construct. Bagozzi and Yi (1988) suggest individual item reliability and composite reliability. Individual construct reliability is tested for the constructs that have more than two or three items. The relationships among the items for each variable are examined to test whether they measure the same construct. Cronbach's alpha is the most popular reliability coefficient in social science research to test individual item reliability. It involves computing the average of the correlation among the responses to all possible pairs of items. The coefficient alphas of research variables are indicated in Table 3. All scales exhibit sufficient reliability as they exceed or near to the reliability guidelines of 0.7 by Nunnally (1978) after deleting low-to-total correlated items except that for informal controls from interaction. The coefficient alpha of informal controls from interaction is 0.668 and this is acceptable as it is slightly below 0.7.

Insert Table 3

LISREL (LInear Structural Relations) modeling is used to investigate the composite reliability (Joreskog and Sorbom, 1989).. Composite reliability is the stability of the scale based on the assessment of internal consistency of the constructs measuring the same latent variable for the collected data. The composite reliability ranges from 0.490 to 0.994 that shows moderate to high reliability. This indicates that a significant portion of variance in latent variable is explained by the variance of measured variables.

In this study, the content and construct validity are tested. Content validity, that tests whether the measurement is sound and complete, is assured through the extreme care taken in the development of items that measure the constructs and subjecting them to various stages of pilot testing. The items used for measuring EDI controls, implementation and performance, which were adapted from the previous studies, were reworded and modified during the pilot test to better measure the underlying concept and to better reflect industry practices.

Construct validity is assessed using convergent and discriminate validity. Confirmatory factor analysis is used to test a priori theoretical structure against data rather than derive an empirical factor structure that cannot be interpretable in view of theoretical perspective. Anderson and Gerbing (1988) propose that convergent validity could be investigated from the measurement model by finding whether the estimated parameter of each construct is significant. As Table 4 indicates, the significant t-values of the parameter estimates of the 12 constructs suggest the presence of convergent validity.

Insert Table 4

Discriminate validity can be indicated by the low correlation with other latent variables from which they should conceptually and theoretically differ. A reasonable measure of discriminant validity is to determine whether the measured variables for each latent variable converge on their corresponding true scores that are unique from other latent variables. The correlation between latent variables needs to be significantly lower than unity in order to achieve discriminant validity. This requires a comparison of one model where all the correlation among variables are not constrained to unity (the correlation are freely estimated) with another model where one of them is constrained to unity (Venkatraman and Ramanujam 1987). There are 11 different models including unconstrained one according to whether each path is constrained to unity or not.

A significantly higher χ^2 value for the constrained model than unconstrained one can indicate the support for discriminant validity. All the χ^2 differences are significant. This generally indicates the correlation between latent variables is significantly lower than unity. A significantly higher χ^2 value for the constrained model than unconstrained one indicates the support for discriminant validity. From the test of χ^2 differences, the correlation between latent variables was significantly lower than unity. This provides the reasonable support for conceptualization of EDI controls in terms of three dimensions and the distinct constructs of implementation success and performance.

5. Data Analysis and Results

This study tests the structural relation among controls, implementation success, and performance using LISREL (Joreskog and Sorbom, 1989). The structural model is represented as Figure 1. The observed variables are enclosed in squares or rectangles. The latent variables are enclosed in circles or ellipses. A one-way path between variables indicates a hypothesized direct effect of one variable to another. The non-existence of an arrow between two variables means that one variable does not have a direct effect on another.

The chi-square is 59.785 with 25 degrees of freedom for the model. P value is 0.0001. The model goodness-of-fit index is 0.906, which is a measure of the relative amount of variables and covariance jointly accounted for by the mode. The adjusted-goodness-of-fit is 0.794. Root mean square residual is 0.136, which is a measure of the average of the residuals. These measures of overall fit indicate the explanatory power of the model.

Significant causal coefficients are found in the relation between; formal controls and implementation success, formal controls and performance (direct, indirect, and total effects are significant), informal controls and performance (direct and total effects are significant) automated controls and performance (indirect effects are significant), implementation success and performance (Table 5). These results indicate that formal and automated controls are positively related to implementation success and that formal controls as well as implementation success increase the performance. Informal and automated controls significantly affect performance only directly and indirectly, respectively. The significant indirect effect of automated controls on performance is due to the significant effect of the same

controls on the implementation success. Formal controls indirectly affect performance through their effect on implementation success. Further, these controls are directly necessary for the high EDI performance regardless of the extent of implementation.

Insert Table 5

6. Discussion and Implications

Based on the results in this study, the administration of EDI security and integrity can be improved when it is focused on formal, informal, and automated controls. The significant effect of formal control on the implementation success and performance indicates that the use of formal controls needs to be evaluated and planned for during the development of an integrated EDI environment. Formalized procedures and standards are accepted as the basic controls for EDI implementation among Korean companies in order to enable efficient and effective flow of standardized messages across different departments and trading partners.

The direct significant effect of informal controls on performance shows that these controls are vital for the attainment of high performance. EDI adopters have enhanced risk recognition and sense of responsibility, and experience in order to ensure high performance from the system although they are not directly necessary for the system implementation success. It takes times for informal learning of EDI adopters and informal controls to be formed. The short history of EDI implementation in Korea may partially make it difficult to explain the relationship between informal controls and implementation success.

Although informal controls don't have significant indirect effect on the extent of implementation success, they have significant direct effect on performance. This indicates that Korean companies rely on informal controls characterized by social obligation, a sense of belonging to the overall organization and understanding of one's place in it regardless of the extent of implementation. EDI adopters depend on VAN service providers or potential trading partners for the provision of controls and the reactive implementation process of controls leads to insignificant relationship between informal learning and socialization of EDI staff members and EDI implementation success. If external trading partners and VAN service providers structure and formalize much of the work processes for EDI implementation, the recognition of risk or responsibility of EDI staff members may not be high.

However, automated controls are required only in proportion to the extent of EDI implementation. The significant indirect effect of automated controls on performance through implementation success indicates the importance of automated controls as the EDI implementation proceeds. It is essential to audit through the computer because the paper documents are replaced by electronic data and the transaction processes are controlled in an automated fashion. These controls should be built in during the development of new system as it is very difficult and expensive to do so on a reactive basis after IS managers and EDI staffs have created the environment.

High cost and expertise required for the development of automated controls necessitate the proportional level of implementation in order to make them beneficial and cost-effective. EDI adopters could not afford the expenses and other IS resources needed for the installation of automated controls unless the implementation of EDI proceeds. EDI adopters believe in the effectiveness of automated controls and feel strongly the necessity of these controls as their use increase.

Formal controls directly and indirectly affect implementation success and performance, while other controls have either direct or indirect effect. Hence, path coefficient analysis suggests that formal controls are the most important controls. The use of informal and automated controls can be stimulated after management introduces formal controls. Formal guidelines and procedures can help users understand and adapt to new technology increasing their internalization and commitment. Formal role relationships and expectations become socially embedded as socialization progresses incrementally (McGrath 1984). Formal rules and policies can increasingly mirror informal understanding and commitments especially in inter-organizational relations (Ring and Van de Ven 1994). The possible system abuse can be also prevented if the information of severe penalty is widespread among employees through the periodic announcement of the contents of penalty specified in formal policies. In this respect, formal policies can enhance the faithfulness of employees and increase informal controls.

8. Conclusions

This study tests a causal path model that considers the impact of EDI controls on performance. The measurement model included more than one constructs for each latent variable, i.e. formal, informal, and automated controls, implementation success, and performance. Confirmatory factor analysis using LISREL indicate high reliability and validity of the instruments. The causal path model is derived based on IS control theory, technology innovation studies, and EDI studies. The significant direct and indirect effects are examined: Formal controls directly and indirectly affect performance; Informal controls directly affect performance, while automated controls indirectly affect performance through their effect on implementation success. Formal controls turn out to be the most important from both path coefficient analysis. The test results of hypotheses are summarized in Table 6.

Insert Table 6

The results of this study show the effectiveness of controls and this may motivate EDI managers to invest in controls. The value of controls is not self-evident until a major loss occurs. Information about large-scale losses is often suppressed because of management's reluctance to publicize the vulnerable state of system and fear of losing organizational credit. Although it is still difficult to quantify the benefits of EDI controls, the positive relationship between EDI controls and performance may lead management to perceive that EDI controls can add value to the business. When EDI is integrated with internal applications and linked with many trading partners communicating diverse EDI documents, EDI controls need to be appropriately used. EDI staffs may consider developing policies and procedures regarding proper use of information system in the first place.

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Tables and Figures

Table 1: Latent variables, Constructs, and Measures for EDI

Latent variables	Constructs	Measure Description	sources
formal controls	formal application controls (FC1)	• system change control by authorization (FC1-1) • integrity check of the message before processing in the application (FC1-2)	adapted from Chan et al. (1993) ISACA (1990) Jamieson (1994) Marcella and Chan (1993)
	formal communication control (FC2)	• transaction log for the possible errors and collapse (FC2-1) • appropriateness of system login procedures using password (FC2-2) • integrity check after generating EDI messages (FC2-3) • authentication of trading partners after receiving EDI messages (FC2-4)	
informal controls	commitment (IC1)	• recognition of possible propagation of errors from one system to another by IS staffs and users (IC1-1, IC1-2) • recognition of the importance of their responsibility by IS staffs and users (IC1-3, IC1-4)	adapted from Jaworski et al. (1993)
	experience (IC2)	• ability to judge peer's errors in their tasks by experience by IS staffs and users (IC2-1, IC2-2) • ability to cope with the errors effectively through experience by IS staffs and users (IC2-3, IC2-4)	
	interaction (IC3)	• interaction with seniors or peers to cope with problems in their tasks by IS staffs and users (IC3-1, IC3-2)	
automated controls	automated application control (AC1)	• programmed integrity check before processing in application systems (AC1-1)	adapted from Chan et al. (1993) ISACA (1990) Jamieson (1994) Marcella and Chan (1993)
	automated communication control (AC2)	• automated data integrity check before transmission of EDI messages (AC2-1) • automated authentication of trading partners using message code (AC2-2)	

Table 2: Latent variables, Constructs, and Measures for implementation success and performance

Latent variables	Constructs	Measure Description	sources
Implementation success	integration (IMP1)	• integration with five application system (respondent selected))	adapted from Premkumar et al. (1994)
	utilization (IMP2)	• utilization of five application system (respondent selected)	adapted from Premkumar et al. (1994)
Performance	performance improvement (PERF)	• improved relationship by reduced response time (PERF-1) • improved relationship by reduced delay from errors (PERF-2) • improved trust by enhanced confidentiality of documents (PERF-3) • improved relationship by reduced omission or inaccuracy in transmission (PERF-4) • maintenance of trust by protected messages from disclosure to third parties (PERF-5) • increase in efficiency of interdepartmental transaction processing (PERF-6) • increase in accuracy by reduced paper work (PERF-7) • reduction of transaction processing costs (PERF-8)	adapted from Arunchalam (1995), Banerjee and Gohar (1994), Hansen and Hill (1989)

Table 3: Individual Item and Composite Reliability

Latent variables	Constructs	Individual Item Reliability	Composite Reliability
formal controls	formal application controls	0.710	0.814
	formal communication controls	0.791	
informal controls	informal controls from commitment	0.914	0.804
	informal controls from experience	0.834	
	informal control from interaction	0.668	
automated controls	automated application controls	—	0.630
	automated communication controls	0.718	
implementation success	integration	—	0.490
	utilization	—	
performance	performance improvement	0.891	0.994

Table 4: Results of Convergent Validity Tests (*: $p < 0.05$, **: $p < 0.01$)

Latent Variables	Constructs	Standardized Factor Loading	Standard Error	t-value
formal controls	formal application controls	0.800	0.088	9.0763**
	formal communication controls	0.857	0.087	9.854**
informal controls	commitment	0.777	0.086	9.079**
	experience	0.825	0.084	9.865**
	interaction	0.672	0.090	7.478**
automated controls	automated application controls	0.575	0.099	5.798**
	automated communication controls	0.775	0.102	7.616**
implementation success	integration	0.520	0.134	3.882**
	utilization	0.618	0.147	4.211**
performance	performance improvement	0.997	0.068	14.769**

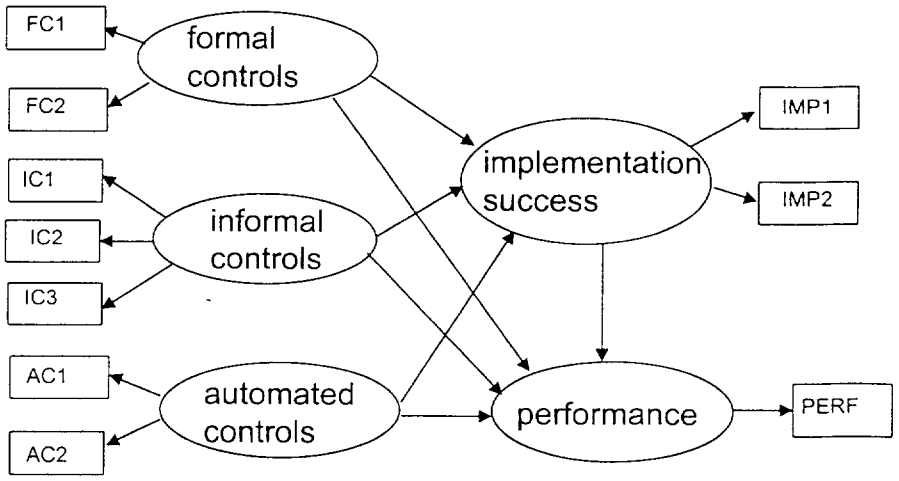

Figure 1: Measurement and Structural Model

Table 5: Causal effects between controls, implementation success, and performance
(MLE: Maximum Likelihood Estimate, *: $p < 0.05$, **: $p < 0.01$)

Causal Path		MLE of causal coefficient	Standardized coefficient	t-value
formal controls → implementation success	direct effect	0.287	0.283	3.076**
informal controls → implementation success	direct effect	0.150	0.114	1.290
automated controls → implementation success	direct effect	0.347	0.278	3.106**
formal controls → performance	direct effect	0.357	0.362	3.165**
	indirect effect	0.048	0.049	1.883*
	total effect	0.406	0.411	3.571**
informal controls → performance	direct effect	0.463	0.364	3.581**
	indirect effect	0.025	0.020	1.110
	total effect	0.488	0.383	3.622**
automated controls → performance	direct effect	0.116	0.096	0.893
	indirect effect	0.058	0.048	1.757*
	total effect	0.174	0.147	1.375
implementation success → performance	direct effect	0.168	0.173	2.142*

Table 6: Results of testing hypotheses

Hypotheses	Results	significance
1-1	accepted	$p < 0.01$
1-2	accepted	$p < 0.05$
2-1	accepted	$p < 0.01$
2-2	rejected	$p > 0.05$
3-1	rejected	$p > 0.05$
3-2	accepted	$p < 0.05$