The Causal Relationships among EDI Controls: A Structural Equation Model

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Abstract

Advances in EDI (Electronic Data Interchange) demand appropriate controls in order to realize the potential benefits from it. Formal, informal, and automated controls are basic parts of EDI controls each of which can be classified into internal and external controls. The state of one of three controls are suggested to affect performance indirectly through their effect on another controls in the research model. The causal relationships are tested using structural equation modeling approach with LISREL. Informal controls turn out to play an important role in the relationships, as they are significantly affected by formal and automated controls and also significantly affect the same controls to have indirect effect on performance. The results of the study indicate that the interrelationships among controls are closely related to system performance. EDI auditors can be provided insights on the causal relationship among controls in order to design controls effectively and improve system performance

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1. Introduction

EDI (Electronic Data Interchange) is the computer-to-computer, or application-to-application, electronic exchange of business information in a standard format.

EDI controls refers to the process through which organization achieves its goals through the implementation of EDI. Management attempts to guide users and staffs of EDI to act in a manner that is conducive to organizational goals and objectives to ensure that the system meets the needs of the organization. EDI controls can safeguard IS resources and ensure data integrity and security in order to accomplish system objectives of timeliness and accuracy of processing. While substantial operating cost may be reduced through the implementation of EDI, these savings can be wiped out by deliberate or erroneous loss of data during data communication. System does not accomplish its intended outcomes if security and integrity of system controls are not sufficient while operating communication networks. Hence EDI controls need to be maintained continuously for system performance.

If EDI adopters do not establish EDI controls, they may not reduce cycle time or administration cost significantly even though they invest much cost for implementation of EDI. If EDI performance level is not satisfactory, EDI controls need to examined in order to see whether they are appropriate. Significant benefits can be hardly expected when EDI controls are not effective.

This article examines the interrelationship among various components of EDI controls. The causal interrelationships are used to develop fuzzy cognitive maps in order to assist EDI auditors design EDI controls. This decision support model is empirically tested with the data collected from Korean companies adopting EDI. A summary of empirical findings, implications for practice, and future research issues are suggested.

2. Components of controls

Frank et al. (1991) suggest factors affecting security-related behaviors of PC users, *formal policies*, *informal norms*, and *PC user knowledge*. The first factor corresponds to formal and the second and third factors can be regarded as informal controls. These three factors represent three forms of organizational controls - bureaucratic control, clan control, and professional socialization (Frank et al., 1991)

While there are many other ways in which EDI controls might be exercised, this study fundamentally deals with three modes of controls; formal, informal, and automated controls. Three types of controls; formal, informal, and automated controls can be combined collectively to achieve the organizational goal as each control has specific contribution to system performance (Lee and Han, 1998a). Formal, informal, and automated controls demand each other for the enhancement of performance. Access control system using password can be one example that show the interaction of three controls for system performance. Formalized procedures of maintaining user password and change control procedures for access control software are formal controls and they demand informal controls such as user recognition of responsibility and faithfulness to the procedures in order to increase the effectiveness of the control system. Automated access control software and embedded audit routines are necessary as the access process becomes routine and repetitive. Automated control can find out and correct invalid or unauthorized accesses more accurately than manual systems in standardized and automated processes.

Formal, informal, and automated controls can be categorized into internal and external controls. Internal controls deal with internal components of EDI systems such as the application system interface while external controls are involved with external EDI systems such as a VAN or trading partner. Internal controls for EDI systems are established to monitor the internal application systems like a production system or a sales system linked to an external network. Internal controls are concerned with internal applications and communication controls, while external controls pertain to interactions with VAN providers and trading partners.

External controls are particularly important for EDI. Because EDI is an interorganizational system, communication is mediated by a VAN or a proprietary network with trading partners. Invalid or unauthorized transactions can be initiated by staffs in a third-party network. Messages could be lost, altered, duplicated, or transposed while they are transmitted through the network. Trading partners must reach an agreement on several technical matters, including transmission standards, message standards, and communication protocols. Trading partner agreements should specify the liability for each party and reduce the chance of future disputes by specifying how each should cope with transaction errors and the violation of trading rules. Once an electronic trading partner relationship is established, the parties must continuously manage such things as contingency planning, mutual training needs, and transmission security.

The aforementioned control dimensions can be used to generate a framework of control types. Internal and external controls can be classified according to two important control dimensions: formality and automation. There are 12 potential control types. Formal controls are developed by management and based on written procedures to be formally abided by. They are composed of four parts:

- internal formal application controls: the degree of using procedures that protect internal applications from errors and

unauthorized access
- internal formal communication controls: the degree of using procedures which ensure that communication is accurate and secure

External formal controls include the following components:

- external formal VAN controls: the degree of using procedures by VAN service providers to ensure security of EDI messages and communication process
- external formal trading partner controls: the degree of using procedures by trading partners to ensure security and integrity of communication

The items for informal controls are adapted from Jaworski *et al*. (1993). They are initiated by organization members relying on the values, judgments and communications of members. Internal informal controls have the following components:

- internal informal controls by IS members: the extent of risk recognition, sense of responsibility, experience, and interaction among colleagues by IS members
- internal informal controls by users: the extent of risk recognition, sense of responsibility, experience, and interaction among colleagues by users

External informal controls include two components:

- external informal controls for VAN: the extent of risk recognition, sense of responsibility, experience, and interaction among colleagues in order to prepare for threats occurred in VAN
- external informal control for trading partners: the extent of risk recognition, sense of responsibility, experience, and interaction among colleagues in order to cope with cross-vulnerabilities from communicating with trading partners

Automated controls indicate the degree of using automated control procedures and methods. Internal automated controls include two components:

- internal automated application controls: the automated routines to detect and correct errors during input, process, and output of data
- internal automated communication controls: security and authentication software: the access control and authentication software to protect EDI systems from unauthorized access and computer abuse.

External automated controls include two components:

- external automated controls by VAN: the extent of using automated control measures for system integrity and security by VAN service providers
- external automated controls by trading partners: the extent of providing automated control measures for system integrity and security by trading partners

3. Casual Relationships among Controls for performance

Controls need to be evaluated in relation to other controls that pertain to the same environment (Parker, 1994). Controls might operate in concert with others in order to protect the system from external threats affect jeopardize different parts of system simultaneously. For instance, the failure of accounting inventory system by external intruder may result in invalid issuance of order to suppliers or inaccurate amount of products. Each component of controls should be independently tested to see whether they can accomplish their purported goals. As controls are closely interrelated, the violation of one control points might immediately demand reinforcement of all the related controls.

Frank et al. (1991) indicates the hypotheses regarding the interaction among *formal policies*, *informal norms*, and *PC user knowledge*. They Indicated the correlation between *formal policies* and *norms* on security-related behaviors are stronger when the user' s level of *knowledge* is low; and the same correlation for *knowledge* turns out to be higher when *formal policies* do not exist and when *norms* are not influential. The causal relationships of formal, informal, and automated controls can be discussed in view of their effects on performance based on the theories of organizational controls and innovation. Firstly, formal controls can be the basis in shaping informal controls. A clearly defined set of policies regarding education of system users can be the basis of enhancing the awareness of users that the violation of rules can significantly affect the integrity and security of systems. Education program on the ethical aspect of system usage can increase the faithfulness and responsibility of employees for system performance. The communication and discussion among employees can be encouraged through the formalized team-work training.

Anthony (1952) indicated that management controls are most effective when different type of controls are used simultaneously to produce synergy effect. Ouchi (1979) suggested that the highest work performance can be possible from the balanced use of multiple controls. Dalton (1971) asserts the interdependent relationship among different type of controls and Hopwood (1972) suggests formal and informal controls should be used simultaneously to control complex organizations. Snodgrass and Szewczak (1990) empirically showed the balanced relation between formal and informal controls. They show that the substitutability of two controls is accepted in only a very limited sense. Jaworski *et al*. (1993) suggests the necessity of control combination by showing the effectiveness of simultaneous use of formal and informal controls. A high or low level of formal and informal controls produce four combinations of control systems, *low control system*, *bureaucratic system*, *clan system*, and *high control system*.

After formal role relationships have been established and the institutionalization of the relationship becomes evident, personal relationships, informal understanding, and commitments increasingly supplement and even substitute for formal rules and policies (Ring and Van de Ven, 1994). Formal role relationships become socially embedded after socialization progresses substantially. EDI staffs rely on their beliefs and experience after they can fully understand formal procedures and routines. As informal controls are founded on the internalization of social values, they may lead to less resistance among EDI staffs than applying formal controls which may cause partner disaffection, low morale, and low levels of commitment (John, 1984). The internalization of mission and procedures can make EDI staffs to follow the present system of controls as taken-for-granted and develop supplementary controls in order to cope with various exceptional mishaps and threat.

Management tries to focus on formal controls firstly as they are observable and easy to be evaluated. However, the role of formal controls can be limited when there exists possibility of diverse risks. The risks from the implementation of EDI can be diverse that EDI staffs need to rely on their experience and social beliefs to cope with inadvertent errors and failures. In addition, the social agreement to comply to the formal rules by management is fundamental to the effectiveness of bureaucratic controls. Formal controls demand the minimum level of commitment. Formalized procedures can not be effective when the desired outcomes or corrective action are not clearly recognized and the commitment from employees does not exist. Hence, formal controls need informal controls in order to improve performance. In order to improve system performance of EDI in this situation, formal and informal can be combined synergistically.

The alternative *proposition* can state that informal controls affect performance indirectly through their effect on formal controls. Although formal controls are suggested to affect other controls, informal norms and understandings of acceptable behavior can motivate management to establish formalized or automated controls or on the contrary, dissuade them from establishing other controls. Ring and Rands (1988) observed situations where organizations reach informal commitments and understandings prior to engagement of formalized terms of agreement. The personal bonds from congruent sense making may produce trust in the other party' s goodwill and will provide flexibility to transcend formally specified roles and demand less formalized rules. Hence, the test of following two propositions can indicate that formal and informal controls affect each other in order to increase performance:

Proposition 1: Formal controls indirectly affect EDI performance though their effect on informal controls.
Proposition 2: Informal controls indirectly affect EDI performance though their effect on formal controls.

Previous studies have suggested the need for the balanced use of two types of organizational control systems, formal or bureaucratic controls which are characterized by a high degree of formalization and informal or cultural control systems which are founded on the moral commitment to, and the internalization of, the norms, values, and objectives of organizations. However, automated controls need to be combined also with other controls in order to high performance in EDI.

Automated control mechanism such as use of security software and audit routines can play a role of deterrents of computer abuse and can be included as major security efforts (Jamieson, 1994). The deterrent role of the security countermeasures are greatly related to the motivational factors (Parker, 1981). The automated controls can delineate the acceptable system use and clarify the system procedures to be followed by being provided warning messages or being automatically logged off. After users are repetitively making access through automatically controlled system and get appropriate warning or even punishment for their misbehavior, they come to recognize the acceptable behaviors from the system and will likely be committed to doing such things if they are afraid of receiving penalties. 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 which are implicit, are equally effective to decrease computer abuse (Straub, 1992).

It is unreasonable to expect automated controls to eliminate all risks as they perform only programmed and limited tasks of monitoring. The possibility of compromising these controls by internal abuse, employees, and external intruders always exists. The commitment of responsible organizational members can highlight the possibility of these system abuse. If their sense of responsibility is heightened, they will be less likely to try to abuse the system by themselves, too. This is especially important for such highly experienced users as system programmers and operators as their computer skills along with occupational role and system privilege may enable them to perpetrate into core system through access control systems. The sense of responsibility of EDI staffs increases the commitment to reduce vulnerability from unauthorized and inadvertent destruction of assets. If the sensitivity and vulnerability of system is recognized by employees, they will be proactive in preventing risks also.

Users can increase their experience after they have used automated controls comprehensively. Experience with EDI are prerequisite to manage a complex network infrastructure monitored by automated controls. The experience of managing different hardware/software and network protocols in conjunction with external network is required. If trading partners lack the experience to implement EDI, organizations will have difficulty in expanding the system unless necessary technical support is provided for them. Hence automated controls demand informal controls for high performance.

Automated controls can increase awareness of the importance of controls systems. After EDI users are controlled repetitively while accessing through automated authentication system, they come to recognize clearly what constitute behaviors that is allowable. Automated controls affect performance as they increase the extent of informal controls by users. Hence, the following two propositions can be suggested:

Proposition 3: Automated controls indirectly affect EDI performance though their effect on informal controls.
Proposition 4: Informal controls indirectly affect EDI performance though their effect on informal controls.

The development and operation procedures for automated controls might enhance the effectiveness of controls. Effective management of the implementation process of access control system is critical and will demand audit during and after implementation (Weber, 1988). For instance, audit software modules are embedded in the application systems in order to recognize transactions having certain characteristics of interest to auditor and this needs to be managed by formal policies. The appropriate change controls for the modules have to be maintained in order to ensure that they are changed by authorization.

After the installation of automated controls, EDI adopters may recognize the importance formal procedures to manage the system (Chan et al., 1993; Jamieson, 1994). It needs to protect transaction logs recorded by these modules from alteration in order to retain a valid audit trail for audit purposes. The retention of audit trails should be considered in terms of accepted media, duration, and types of transactions to be retained for audit purposes. In addition, appropriate reporting and follow-up procedures need to be established to perform timely reviews of exceptions and make countermeasure before they impact internal operations or decision making.

Formalized procedures need to be developed to support development and operation of automated controls. Formal requirement analysis of system including timeliness and accuracy will support making decisions on the extent of automated controls (Lee and Han, 1998b). It will be inefficient to spend much IS resources when the system is not susceptible to errors or delay from system failures are allowable due to long cycle time. The implementation of automated controls in the subsystems needs to be conducted in view of their sensitivity and vulnerability.

After appropriate formal guidelines have been set up, significant attention need to be paid to whether present extent of automation is enough for controls. The significant reduction in paper documents and audit trails demands the changes in controls for traditional manual processing in order to ensure accuracy, timeliness, completeness, and recoverability of high speed EDI transactions (Gunther, 1994; Malley and Thompson, 1994). Unless automated integrity controls are built into the sophisticated EDI application system, EDI system may result in invalid system outcomes and this may lead to impaired relationship and the decision not to implement EDI further between trading partners. In addition, this leads to legal liability, loss of market share, or competitive advantage. It is always prudent for management to focus on preventive controls rather than after-the-fact exception reporting and corrective procedures. Automated application controls can not only assist in timely identification and resolution of critical problems as they occur but may also check the compliance of transactions with accepted standards and prevent errors from reaching into other applications. Hence the following two *propositions* can be suggested:

Proposition 5: Automated controls indirectly affect EDI performance though their effect on formal controls.
Proposition 6: Formal controls indirectly affect EDI performance though their effect on automated controls.

4. Methodology

The survey instrument is validated via field interviews with 10 EDI practitioners and four IS professors. Using the validated instrument, a total of 110 interviews are made. The respondents are EDI staffs or managers. The data are collected using structured interviews with EDI practitioner. The data used in validating the research model are gathered as part of a larger investigation concerning the EDI controls.

The companies which are likely to have adopted EDI in the industries which have used EDI heavily are contacted and their EDI adoption states are confirmed. Publicly available company databases (available from Chollian network service) are used to search the companies.

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

The measure for EDI performance is 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 & 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. The measures for the implementation and performance are summarized in Lee and Han (1998a, 1998b).

5. Results and Discussions

5.1 Assessment of Measurement Properties

The conceptual model with seven latent variables (unobservable construct) need to be tested against data to establish three measurement properties; reliability, content validity, discriminant validity of measures. Reliability and validity tests are conducted for each latent variables and constructs. Reliability is the stability of the scale based on an assessment of the internal consistency of the items measuring the construct for the collected data. Individual item reliability and composite reliability can be examined (Bagozzi and Yi 1988). Individual construct reliability is tested for the constructs which 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 correlations among the responses to all possible pairs of items (Cronbach, 1951). The individual item reliability (coefficient alphas) of research variables are indicated in Table 1. All scales exhibit sufficient reliability as they exceed or near to the reliability guidelines of 0.7 by Nunnally (1978).

Table 1: Individual Item and Composite Reliability

Latent Variables	Constructs	Individual Item Reliability	Composite Reliability
internal formal controls	internal formal application controls	0.7102	0.8129
	internal formal communication controls	0.7907	
external formal controls	external formal VAN controls	0.8605	0.9050

	external formal partner controls	0.7828	
internal informal controls	internal informal controls by IS members	0.8455	0.8386
	internal informal controls by users	0.8737	
external informal controls	external informal controls for VAN	0.8379	0.8939
	external informal controls for partners	0.8291	
internal automated controls	internal automated application controls	—	0.6224
	internal automated communication controls	0.7179	
external automated controls	external automated controls by VAN	0.7765	0.7432
	external automated controls by trading partners	0.6673	
performance	improved relation	0.8910	0.9010
	competitive advantage	0.8681	

LISREL (LInear Structural RELations) modelling is used to investigate the composite reliability. The LISREL package uses confirmatory factor analysis to generate factor loadings that best describe the specified relationships between measures and constructs. Confirmatory factor analysis is used to test a priori theoretical structure against data. This can be contrasted with exploratory factor analysis which derive an empirical factor structure. The exploratory factor analysis often produces the factor structure that cannot be interpretable often in view of theoretical perspective. The analytical procedure by Jöreskog (1971) as implemented in LISREL (Jöreskog and Sörbom, 1993) has been employed to test the measurement models.

If the measurement model specification by Jöreskog is followed, the model for convergent validity can be written as the following system of linear structural relations:

$X = \boldsymbol{L x} + \boldsymbol{d}$

$Y = \boldsymbol{L h} + \boldsymbol{e}$

Where

X = a vector of observed variables for latent independent variables

(formal, informal, and automated controls)

$\boldsymbol{x}$= a vector of latent independent variables;

Y = a vector of observed variables for latent dependent variables

(implementation and performance);

$\boldsymbol{h}$= a vector of latent dependent variables; and

$\boldsymbol{d}, \boldsymbol{e}$= a vector of random errors

Firstly LISREL modeling is used to investigate the composite reliability. Composite reliability is the stability of the scale based on an assessment of the internal consistency of the constructs measuring the same latent variable for the collected data. The relationships among the constructs are examined to test whether they measure the same latent variable. The parameter estimates can be used to calculate the composite measure of the latent variable (Wert, Linn, and Jöreskog, 1974), as follows:

$$\boldsymbol{r}_c = \frac{\left(\sum_{i=1}^{v} \left| l_i \right|\right)^2}{\left(\sum_{i=1}^{v} \left| l_i \right|\right)^2 + \sum Var\left(d_i\right)} \quad \text{where}$$

$\boldsymbol{r}_c$ = composite reliability of latent variable;

v = number of constructs for each latent variable;

l_i = the standardized factor loading relating i to the underlying dimension; and

$Var(d_i)$ = 1- $\left(l_i\right)^2$

The composite reliability ranges from 0.6224 to 0.9050 which shows high reliability. This indicates that a significant proportion of variance in latent variable is explained by the variance of constructs.

Validity is the degree to which an instrument measures the construct under investigation. In this study, the content and construct validity are tested. The content validity indicates the representativeness or sampling adequacy of the content of a measure and concerned with the representativeness of the content of the measure for the universe of the property being measured. In order to enhance the content validity of the instrument, this study adapts the measures used by previous studies and pretests them by practitioners and experts.

Construct validity is assessed using convergent and discriminant validity. Convergent validity tests if all the items measuring a latent variable cluster together and form a single latent variable. Convergent validity could be examined from the measurement model by investigating the significance of estimated parameter of each construct (Anderson and Gerbing, 1988). As Table 2 indicates, the significant t-values of the parameter estimates of the 12 constructs suggest the presence of convergent validity.

Table 2: Results of Convergent Validity Tests (*: $p < .1$, **: $p < .05$, ***: $p < .01$)

Latent Variables	Constructs	Standardized Factor Loading	standard deviation of Error	t-value
internal formal controls	internal formal application controls	0.8240	0.0852	9.6689***
	internal formal communication controls	0.8311	0.0850	9.7738***
external formal controls	external formal VAN controls	0.9520	0.0747	12.7445***
	external formal partner controls	0.8644	0.0777	11.1283***
internal informal controls	internal informal controls by IS members	0.9714	0.0762	12.7516***
	internal informal controls by users	0.7140	0.0858	8.3264***
external informal controls	external informal controls for VAN	1.0033	0.0738	13.6021***
	external informal controls for partners	0.7837	0.0824	9.5071***
internal automated controls	internal automated application controls	0.6041	0.0951	6.3513***
	internal automated communication controls	0.7372	0.0948	7.7771***
external automated controls	external automated controls by VAN	0.8722	0.0839	10.3931***
	external automated controls by trading partners	0.6569	0.0874	7.5187***
performance	improved relation	0.9718	0.0801	12.1288***
	competitive advantage	9,8349	0.0845	9.8801***

Discriminant validity refers to the degree to which a latent variable differs from other ones. It can be indicated by the low correlations 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 which are unique from other latent variables. A rival explanation can indicate that the five latent variables should not be treated as distinct variables. It is needed to show that the three variables of controls are distinct as they have some shades of common meaning. It is the same with implementation and performance.

The correlations between latent variables need to be significantly lower than unity in order to achieve discriminant validity. This requires a comparison of a model where all the correlations among variables are not constrained to unity (the correlations are freely estimated) with the one where one of them is constrained to unity (Venkatraman and Ramanujam, 1987). There are 11 different models including unconstrained one according to whether ϕ_{ij} (the correlation between latent variable i and j) is constrained to unity or not as follows:

(a) Unconstrained Model: all ϕ_{ij} are not fixed
(b) Constrained Model 1: ϕ_{21} is fixed to 1
(c) Constrained Model 2: ϕ_{31} is fixed to 1
(d) Constrained Model 3: ϕ_{41} is fixed to 1
(e) Constrained Model 4: ϕ_{51} is fixed to 1
(f) Constrained Model 5: ϕ_{61} is fixed to 1
(g) Constrained Model 6: ϕ_{71} is fixed to 1
(h) Constrained Model 7: ϕ_{32} is fixed to 1
(i) Constrained Model 8: ϕ_{42} is fixed to 1
(j) Constrained Model 9: ϕ_{52} is fixed to 1
(k) Constrained Model 10: ϕ_{62} is fixed to 1
(l) Constrained Model 11: ϕ_{72} is fixed to 1
(m) Constrained Model 12: ϕ_{43} is fixed to 1
(n) Constrained Model 13: ϕ_{53} is fixed to 1
(o) Constrained Model 14: ϕ_{63} is fixed to 1
(p) Constrained Model 15: ϕ_{73} is fixed to 1
(q) Constrained Model 16: ϕ_{54} is fixed to 1
(r) Constrained Model 17: ϕ_{64} is fixed to 1
(s) Constrained Model 18: ϕ_{74} is fixed to 1
(t) Constrained Model 19: ϕ_{65} is fixed to 1
(u) Constrained Model 20: ϕ_{75} is fixed to 1
(v) Constrained Model 21: ϕ_{76} is fixed to 1

A significantly lower value for the constrained model than unconstrained one can indicate support for discriminant validity. As Table 3 shows, all the χ^2 differences are significant. This indicates the correlations between latent variables are significantly lower than unity. This supports conceptualization of EDI controls in terms of six dimensions and the distinct latent variables of implementation and performance.

Table 3: Results of Chi square difference test of discriminant validity

(*: $p < .1$, **: $p < .05$, ***: $p < .01$)

Alternative Models	Chi Square	df	Chi-square difference	df difference
Unconstrained Model	78.09	52	—	—
Constrained Model 1	105.12	53	27.03***	1
Constrained Model 2	109.93	53	31.84***	1
Constrained Model 3	117.70	53	39.61***	1
Constrained Model 4	88.21	53	10.12***	1
Constrained Model 5	97.87	53	19.78***	1
Constrained Model 6	121.42	53	43.33***	1
Constrained Model 7	113.44	53	35.34***	1
Constrained Model 8	138.58	53	60.48***	1
Constrained Model 9	89.82	53	11.73***	1
Constrained Model 10	93.34	53	15.25***	1
Constrained Model 11	165.94	53	87.85***	1
Constrained Model 12	118.55	53	40.45***	1
Constrained Model 13	79.87	53	1.77	1
Constrained Model 14	95.04	53	16.95***	1
Constrained Model 15	135.52	53	57.43***	1
Constrained Model 16	91.43	53	13.34***	1
Constrained Model 17	84.74	53	6.64***	1
Constrained Model 18	173.90	53	95.81***	1
Constrained Model 19	80.84	53	2.75*	1
Constrained Model 20	91.60	53	13.50***	1
Constrained Model 21	106.84	53	28.74***	1

5.2 Test of Research Model

This study tests the structural relation among controls and performance using LISREL. LISREL provides several advantages over other multivariate techniques. First, LISREL can be used to validate relationships between theoretical constructs (latent variable) with multiple measured variables (construct). The same linear model by regression analysis cannot accommodate multiple measures of the same latent variable. Second, simultaneous causation among the observed variables can be examined. The overall fitness of the models can be indicated by various fitness indexes including Chi-square statistic. Chi-square difference test can be used to find out the "best" fitting model after the Chi-square test statistic of alternative models such as null, saturated, theoretical, constrained and unconstrained models are compared. Third, it can investigate the causal link in detail rather than a mere empirical association among variables. Intricate causal links including recursive or nonrecursive and direct or indirect relationships among constructs can be examined in order to better characterize real-world processes for the development of theory (Blalock, 1969). It is impossible to test the same relationship through by multivariate techniques.

The structural equation for the research model that indicates a positive and significant relation between EDI controls and performance can be written in a general form as the following system of linear structural relations:

$\boldsymbol{h} = \Gamma \boldsymbol{x} + \mathrm{B}\, \boldsymbol{h} + \boldsymbol{z}$ where

Γ = matrix of structural coefficients relating independent latent variable to dependent latent variable;

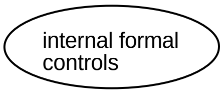
B = matrix of structural coefficients relating dependent latent variable to other dependent latent variable;

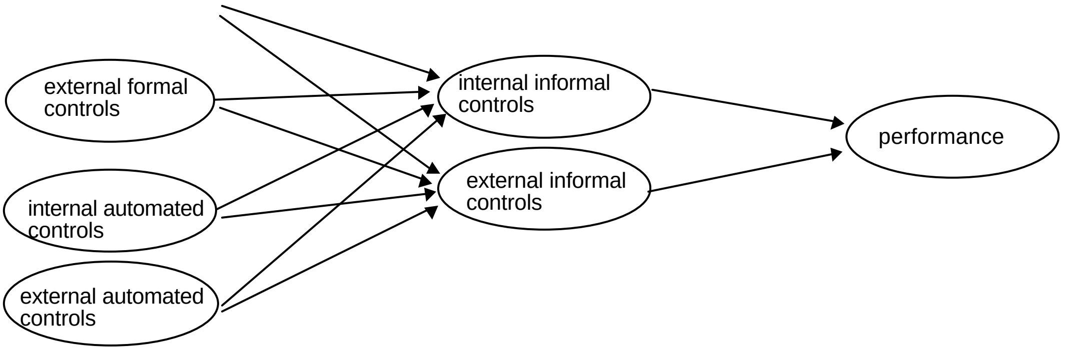
$\boldsymbol{x}$ = independent latent variable;

$\boldsymbol{h}$ = dependent latent variable; and

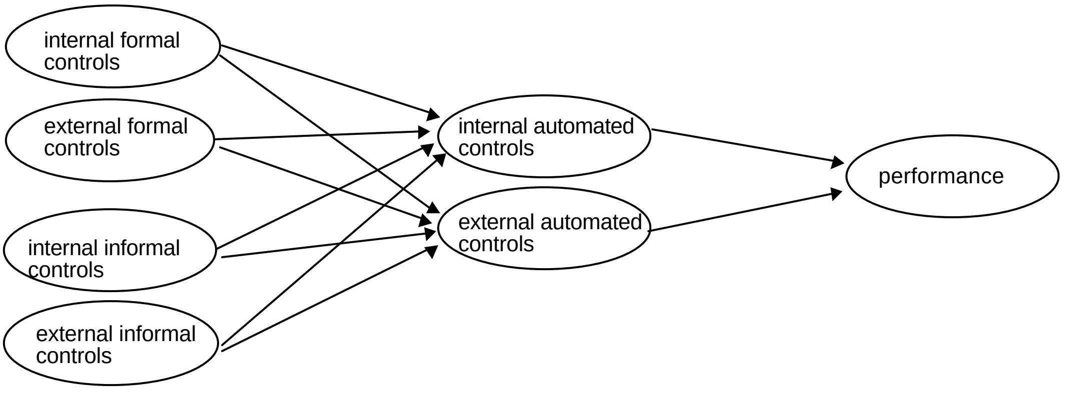
$\boldsymbol{z}$ = residuals of dependent latent variable

The path diagrams for structural model can be represented as Figure 1. It effectively communicates the basic conceptual ideas of research model and represents the corresponding algebraic equations of the model. The latent variables such as $\boldsymbol{x}$ and $\boldsymbol{h}$ are enclosed in circles or ellipses following the notation suggested by Jöreskog and Sorbom (1989). A one-way arrow between two variables indicate a hypothesized direct effect of one variable on another. The non-existence of an arrow between two variables means that it is assumed that one variable does not have direct effect on the other. Three path diagrams are suggested to test the indirect effect of controls on performance through their effect on other controls. For example, the first path diagram is suggested to test whether formal and automated controls affect performance through their effect on informal controls. As it is difficult to test the indirect effect of three controls on performance simultaneously in one structural model, three models are separately constructed. For instance, in order to test the *proposition* 1 and 2, the estimates of four causal paths, γ_{11}, γ_{12}, γ_{21}, γ_{22} need to be tested in Model 1 and 3,respectively. It should be noted that the paths in two models cannot be simultaneously examined. If these causal relationships are included in one structural model, it is difficult to separate the indirect effect of one controls because of the recursive relation among constructs.

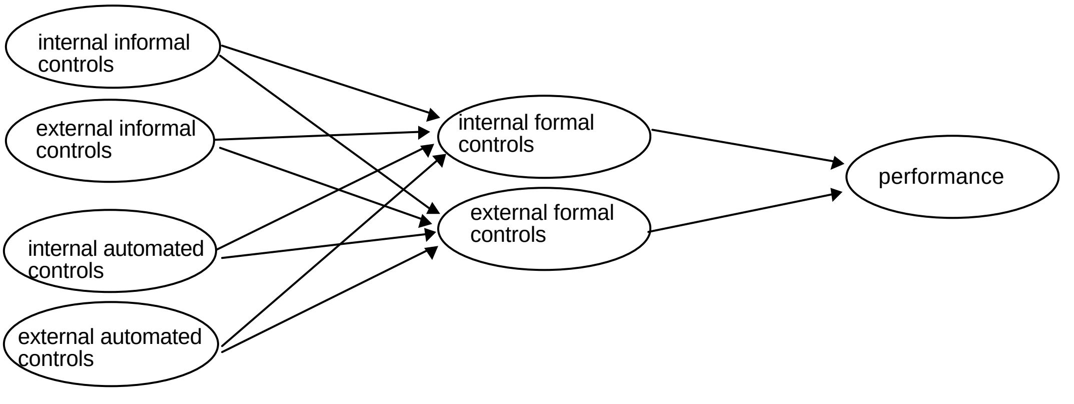




(a) Model 1



(b) Model 2



(c) Model 3

Figure 1: Three Causal Path Models

Structural equations can de derived from the path diagram. There will be one equation for each variable which has a one-way arrow pointing to it and this variable is a left-hand variable. The right-hand side of each equation is the sum of terms which is the product of the coefficient associated with the arrow pointing to it and the variable from which the arrow is coming. For instance, structural equations for Model 1 are as follows:

$$h_1 = g_{11}x_1 + g_{12}x_2 + g_{13}x_3 + g_{14}x_4 + z_1$$
$$h_2 = g_{21}x_1 + g_{22}x_2 + g_{23}x_3 + b_{24}x_4 + z_2$$
$$h_3 = g_{11}x_1 + g_{12}x_2 + g_{13}x_3 + g_{14}x_4 + g_{21}x_1 + g_{22}x_2 + g_{23}x_3 + g_{24}x_4 + b_{31}h_1 + b_{32}h_2 + z_3$$

x_1 = internal formal controls

x_2 = external formal controls

x_3 = internal automated controls

x_4 = external automated controls

h_1 = internal informal controls

h_2 = external informal controls

h_3 = performance

z_1, z_2, z_3 = residuals of dependent latent variable

The model fit of three models are indicated in Table 5. The 7 fit indices suggest good fit for the proposed models. The chi-square index of three models are significant. The model goodness-of-fit indices of three models which is a measure of the relative amount of variables and covariances jointly accounted for by the mode, are greater than over 0.9.

Table 5: Model Fit of Three Models

	Model 1	Model 2	Model3
Chi-square	90.8160 (p=0.0049)	96.0722 (p=0.0007)	85.9444 (p=0.0028)
Degrees of Freedom	59	56	53
Goodness of Fit Index (GFI)	0.9018	0.9048	0.9091
Adjusted Goodness of Fit	0.8252	0.8217	0.8199
Normed Fit Index (NFI)	0.9213	0.9168	0.9255
Non-Normed Fit Index (NNFI)	0.9538	0.9388	0.9468
Comparative Fit Index (CFI)	0.9701	0.9623	0.9690
Root Mean Square Residual (RMSR)	0.1248	0.1182	0.1835

The significant indirect effect is found when the causal influence of one controls on the other are significant. For instance, 7 of 8 causal paths from formal and automated controls to informal controls in Model 1 are significantly positive and this leads to significant indirect effect of formal and automated controls (Table 6). Informal controls are significantly related to performance. Formal and automated controls have a significant indirect effect on performance through informal controls in Model 1. This shows that formal procedures and automated control software can be more effective when the users are responsible, faithful, and experienced. Users need to discuss and cooperate with their colleagues to adapt and use formal and automated controls appropriately.

Table 6: Causal effects between controls and performance in Model 1

Formal and automated controls are independent variables.

MLE:Maximum Likelihood Estimate, *: $p < .1$, **: $p < .05$, ***: $p < .01$

Causal Path	direct or indirect effect	MLE of causal effect	Standardized effect	t-value
internal formal controls → internal informal controls	direct	0.4594	0.3672	3.6829***
internal formal controls → external informal controls	direct	0.2487	0.1904	1.8062**
external formal controls → internal informal controls	direct	0.2560	0.2046	2.0458**
external formal controls → external informal controls	direct	0.5344	0.4091	3.8295***
internal automated controls → internal informal controls	direct	0.2060	0.1647	4.1426***
internal automated controls → external informal controls	direct	0.0189	0.0145	0.4395
external automated controls → internal informal controls	direct	0.1191	0.0952	2.1089**
external automated controls → external informal controls	direct	0.2459	0.1882	3.299***
internal informal control → performance	direct	0.5240	0.6939	2.1285**
external informal controls → performance	direct	0.2862	0.3958	1.2771*
internal formal controls → performance	indirect	0.3119	0.3302	3.1869***
external formal controls → performance	indirect	0.2871	0.3039	2.9453***
internal automated controls → performance	indirect	0.1134	0.1200	2.3292***
external automated controls → performance	indirect	0.1328	0.1405	2.7186***

Although 7 out of 8 causal links from formal and informal controls to automated controls are significantly positive in Model 2, the influence from automated controls to performance are not strongly accepted as only one of two paths are significantly positive (Table 7). This may be also due to the insignificant path from internal formal controls to external automated controls. This leads to the result that one of four independent latent variables, internal informal controls fail to affect performance indirectly through automated controls in Model 2. EDI adopters rely on VAN service providers to establish automated controls because of high expense and expertise required of them. Internal formal procedures concerning the management of internal applications appear to be irrelevant to external integrity and security control services provided by VAN. All the other formal controls and informal controls significantly affect performance indirectly in Model 2. Formal rules, standards, and user recognition of security and integrity are prerequisite in order to obtain significant benefits from automated controls.

Table 7: Causal effects between controls and performance in Model 2

Formal and informal controls are independent variables.

MLE:Maximum Likelihood Estimate, *: $p < .1$, **: $p < .05$, ***: $p < .01$

Causal Path	direct or indirect effect	MLE of causal effect	Standardized effect	t-value
internal formal controls → internal automated controls	direct	0.0787	0.1772	1.5575*
internal formal controls → external automated controls	direct	-0.0223	-0.0251	-0.5301
external formal controls → internal automated controls	direct	0.5554	1.2500	6.2837***
external formal controls → external automated controls	direct	0.8319	0.9351	10.7734***
internal informal controls → internal automated controls	direct	0.4684	1.0541	4.7500***
internal informal controls → external automated controls	direct	0.3093	0.3477	3.7356***
external informal controls → internal automated controls	direct	0.1020	0.2294	2.1951**
external informal controls → external automated controls	direct	0.1277	0.1435	2.8534***

internal automated control → performance	direct	0.1838	0.0681	0.8610
external automated controls → performance	direct	0.6097	0.4521	3.3907***
internal formal controls → performance	indirect	0.0009	0.0007	0.0258
external formal controls → performance	indirect	0.6093	0.5078	7.4536***
internal informal controls → performance	indirect	0.2747	0.2289	3.6541***
external informal controls → performance	indirect	0.0966	0.0805	2.8825***

In Model 3, only informal controls affect performance indirectly through formal controls (Table 8). Only 1 of 4 paths from automated controls to formal controls and one of two paths from formal controls to performance are significantly positive. This can explain the relatively low support for the indirect effects of automated controls through formal controls. It appears that EDI adopters develop security software or introduce them from VAN service providers or vendors without establishing formalized procedures to manage them. They come to rely on the automated procedures provided by VAN while they participate in the network services, they would not further establish authentication and authorization procedures for the system. As it turns out that automated controls affect significantly informal controls in Model 1, EDI adopters depend on informal learning and internalization of users to monitor controls rather than developing formal rules and operational procedures after their system is monitored automatically by VAN network services.

Table 8: Causal effects between controls and performance in Model 3

Informal and automated controls are independent variables.

MLE:Maximum Likelihood Estimate, *: $p < .1$, **: $p < .05$, ***: $p < .01$

Causal Path	direct or indirect effect	MLE of causal effect	Standardized effect	t-value
internal informal controls → internal formal controls	direct	0.6701	0.5270	5.7522***
internal informal controls → external formal controls	direct	0.7747	0.5523	6.1361***
external informal controls → internal formal controls	direct	0.1486	0.1169	1.3842**
external informal controls → external formal controls	direct	0.2283	0.1627	1.8558**
internal automated controls → internal formal controls	direct	-0.0495	-0.0390	-0.3652
internal automated controls → external formal controls	direct	-0.3710	-0.2645	-1.6353
external automated controls → internal formal controls	direct	0.0819	0.0644	0.5738
external automated controls → external formal controls	direct	0.4410	0.3144	1.7621**
internal formal control → performance	direct	0.8151	1.1766	15.8014***
external formal controls → performance	direct	-0.0326	-0.0519	-0.9474
internal informal controls → performance	indirect	0.5209	0.5915	5.7431***
external informal controls → performance	indirect	0.1137	0.1291	1.3322*
internal automated controls → performance	indirect	-0.0283	-0.0321	-0.2656
external automated controls → performance	indirect	0.0524	0.0595	0.4725

Formal and informal controls affect each other and this reciprocal influence produces a significant indirect effect on performance. This is also the case for informal controls and automated controls On the other hand, only one-way weak influence is found between formal and automated controls to affect performance. That is, only external formal controls affect performance indirectly through automated controls and automated controls fail to affect performance indirectly through formal controls.

Informal controls turn out to be influenced strongly by formal and automated controls and they significantly affect the other controls subsequently. Hence in order to increase performance of system, formal and automated controls need appropriate extent of risk recognition, sense of responsibility, experience, and interaction of system users and IS members. When organizational members have informal controls, this in turn leads to enhancement of formal rules, standards, and security software to increase system effectiveness.

Formal and informal controls mirror each other for the attainment of system objectives. EDI staffs reached informal understandings and commitment as they follow the formal role and responsibility given to them repeatedly over time. Personal relationship among them increasingly compensate for the formal role relationship within organizations as they execute commitment and enhance the understandings of their role relationships with their organizations. Further, these informal norms can lead to formation of formalized procedure and rules. These informal commitments can become institutionalized through repetitive execution of behaviors by EDI staffs. A formally specified procedures can be established from these norms after they begin to share the idea that these behaviors are simple "the way things are done."

Informal controls can reinforce formal rules as they may represent the extent of the perception of certainty and severity of "sanctions" against committing a deviant act. When potential offenders perceive high risk of being punished or penalties for violation of procedures are severe, they are dissuaded from illicit behaviors (Straub, 1992). Although formal procedures are essential to protect and safeguard the system, It is equally important for security administrators to make the presence of formal controls felt through enforcing and distributing information about control policies regarding system usage. The severity of punishment needs to be clearly recognized by system users through education and training in order to prevent anti-social acts by them.

The balanced use of the formal and informal controls lead to high performance. Excessive monitoring of the terms in formal rules and formalization can bring about conflict and distrust among EDI staffs. Formal controls often conflict with the needs of flexibility and autonomy of employees. Employees may maintain their autonomy in their position and hope to rely on more their discretion in performing tasks in the interdependent work environment that emerge with time. In addition, informal controls without formal procedures may also lead to low effectiveness of control systems. The most critical risk in EDI systems can result from the mutual reliance among employees or trading partners not well founded in formalized rules and agreements. Mere reliance on trust that are involved between the sender and the receiver may lead to high risks from "opportunistic behavior" that lead to unauthorized disclosure to external parties and alteration and amendment of messages. Hence, management needs to set up control procedures such that they can at least prepare for errors and omissions that lead to contingent loss.

Automated controls need to be used also with Informal controls in a balanced way. They mirror each other for the high performance of the system. Informal understandings of the way to use automated controls and commitment of users to can determine the effective of the latter as users may increase the faithfulness to follow the routines indicated by the controls. There exist always the path through which the system can be accessed and automated routines can not absolutely protect system from every authorized access. EDI managers need to rely on the faithfulness and user recognition of their responsibility at least to some extent.

Informal controls can help automated controls develop over time. It is possible for automated controls to mirror the informal understandings and commitments reached by employees. After users adapt to the use of automated controls and increase their commitment to these procedures, they find out the problems of existing controls and way to enhance these controls. In addition, the reliance on the goodwill of users and an exclusion of automated controls to monitor communication process can create the very conditions for the misue of trust and place an the organization in jeopardy due to the rapid propagation of message errors and effects of failures of applications.

6. Conclusion

This paper examines the influence of the relationships among formal, informal, and automated controls on system performance. The measures of three controls are composed of internal and external controls to tap the internal and external aspects of controls in interorganizational system. Measurement model is tested using confirmatory factor analysis and high reliability and validity are validated. Based on research in organizational controls and EDI implementation, a research model is developed concerning the relationships of controls. Three path diagrams are separately suggested in order to test 6 *proposition* concerning indirect effects of controls. Three models are empirically validated using structural modeling (LISREL). Data analysis of responses from 110 Korean firms indicate that significant causal relationships exist between; formal and informal controls, automated and informal controls. It turns out that formal and automated controls affect performance indirectly through informal controls and that informal controls in turn affect performance through formal and automated controls. Hence, informal controls are most related to other controls to increase system performance. Table 10 summarizes the results of testing *propositions* related to indirect effects of internal and external controls for formal, informal, and automated controls.

Table 10. Results of testing propositions

Propositions	dependent controls are internal		dependent controls are external	
	results	significance	results	significance
1	accepted	$p < 0.01$	accepted	$p < 0.01$
2	accepted	$p < 0.01$	accepted	$p < 0.1$
3	accepted	$p < 0.01$	partially accepted	$p < 0.01$
4	accepted	$p < 0.01$	accepted	$p < 0.01$
5	rejected	$p > 0.1$	partially accepted	$p > 0.1$
6	accepted	$p > 0.1$	partially accepted	$p < 0.01$

6. Implication for Practitioners

Design of EDI controls is seldom a simple task as it demands consideration of complex interrelationships among various components of controls. The problem of EDI controls design is to discover that the balanced combination of various controls which must effectively allow a particular EDI adopter to accomplish their intended objectives. EDI auditors have to enforce three major components of EDI controls (Lee and Han,1998a), formal, informal, and automated controls. These can be combined to achieve the organizational goal. It seems unnecessarily limited to focus on one type of control exclusively because a single type of control does not fully explain the complete set of controls operating within an organization (Anthony, 1952; Hopwood, 1972; Khandwalla, 1972). Hence if a firm is planning to initiate designing of EDI controls, the study findings of interrelationships among controls suggest important strategies for successful implementation.

The initiator could use a variety of formal and automated procedures including standards, agreements, contingency plan, security software, and integrated test facility. However they need to consider that these controls can be less effective without any enhancement of informal controls by users, i.e., risk recognition, sense of responsibility, experience, and interaction process. This indicates that management need to assist internalization process of users after formalized and computerized procedures are adopted. User commitment to controls is critical to the successful adoption of controls. Hence as a first step in the support strategy, management needs to market the benefits of controls to users and partners to enable them to appreciate the need of controls. If users can convince the benefits from following controls, they will be encouraged to comply to the procedures despite increased workload. Providing education and training is perhaps the most effective support strategy since it increases user faithfulness and awareness as well as learning and adjustment.

The results of the study suggest that EDI users and staffs need to become more committed to formal and automated procedures and recognize potential for breaches of EDI controls. The overall level of concern for security should estimate the potential risk inherent in highly connected and integrated EDI system and refine the activities for controls. They have to connect conceptually the extent of benefits from the implementation of EDI and level of controls. The risks of potential behavioral compromise in EDI system can be mitigated through proactive promotion of the guideline for acceptable behavior. The core values of integrity and security of system can be constantly communicated through various means such as seminars, workshops, training, and in-house newslestters and posters. Interaction and information sharing among EDI managers will make them clearly understand target and accountability of EDI controls and may reinforce the effectiveness of EDI controls. The effectiveness of formal and automated procedures depends on the communication of management's expectations through these controls to EDI users and managers. These communication process not only provides a sense of the management's overall direction but elicits commitments from EDI users and staffs.

7. Implication for Researchers

The results of this study provide the insights of control practices in the specific interorganizational system, EDI. The research model identifies the causal relationship among control modes. Such model will provide a contingency prescription on the use of a specific control mode. The examination of the interrelationships among controls will help design multiple control modes as a portfolio. The concepts of formal, informal, and automated controls need to be applied synergistically in EDI management environment given that EDI is one major vehicle of organizational transformation for competitive advantage.

It is needed, however, to investigate organizational and IS characteristics that could moderate the relationships among controls. Different organization contexts can fit the use of each of these controls. For example, increased interdependence would increase the use of a informal control system for the better consequence of an organization. Formal and informal controls can compensate for each other according to other organizational context such as size and tasks characteristics. For example, large organization utilize bureaucratic controls (Hickson *et al*., 1969) and organizations with assembly line technologies utilize bureaucratic controls (Woodward, 1958). The relationship between EDI controls and organizational context can be theoretically studied based on the large body of empirical research on organizational controls. The industry and organizational characteristics such as technological change, organizational size, and sophistication of IS may affect the appropriate levels and extent of EDI controls. It will be interesting to examine the role of various factors that could determine the direction and intensity of the causal relationships among controls.

The study suggest that EDI controls are relatively complex, multidimensional issues. Besides the major three dimensions of controls, there can exist other dimensions of controls and they can in turn interact with other ones. For instance, control mechanisms can be segmented according to different transaction streams (Sia and Neo, 1997). The risk profiles of the transaction streams need to be matched with costs of employing specific control mechanisms. It is not efficient if an entire process is subjected to the same controls when only a small amount of a company's transactions are in fact problematic. Control procedures can add value to the business if they are directed to the transactions that are sensitive for system performance. Managers designing such control segmentation need to cautiously make decisions on segregation criteria in order to balance the efficacy and cost of controls.

The introduction of information sharing system that cross organizational boundaries demand consideration of complexity in the operating environment of systems and changes in the control design in order to implement system successfully. It is needed to incorporate analysis carried down to the level of application as well as interorganizational and enterprise levels, to the extent that interorganizational dependencies and internal integration increase requirements for enhanced controls. The efforts toward various dimensions of controls can be the basis to understand accurately the interrelationships among EDI controls and their contribution for performance.

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