The Relationship between Security Controls and System Performance in B2B Systems

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Abstract

The evaluation of EDI controls is important in ensuring the high performance of an EDI system. Although penetration level is strongly associated with performance, the benefits derived arise from the usage level of EDI controls. This suggests that EDI controls affect the relationship between EDI implementation and performance. Research hypotheses have been empirically tested using responses from Korean companies that have adopted EDI.

It has been shown that the integration and utilization of EDI affects its performance. When EDI is highly integrated, formal, informal, and automated controls must be enhanced in order to provide high performance. High utilization affects performance only when automated controls are completely implemented. Empirical analysis confirms that EDI controls affect the relationship between EDI implementation and performance.

Introduction

Electronic data interchange (EDI) is the inter-company exchange of business data in a standard format via a telecommunication network between complementary computer applications. Benefits from the implementation of EDI include improved customer service, decreased administrative cost, increased sales, and improved control of data and appear widespread in many EDI adopters. However, many EDI adopters still have had mixed success [24]. For instance, EDI may not provide the desired benefits if purchase order information received electronically from customers is not correct, thus affecting the internal processes of the organization by producing invalid system outcomes. Unsatisfactory security is an influential factor in decisions not to use EDI or not to expand an EDI system. This, in turn, directly affects the perceived effectiveness of the system [5].

While administrative and operating costs may be reduced due to EDI, those savings may be negated out by deliberate or erroneous loss of data during communication. Organizational outcomes such as improved service, system response time, and cost savings depend more on the usage level of EDI controls when the extent of implementation is high. It becomes more cost effective to establish higher usage level of controls if implementation is higher. The type and extent of controls required for high performance depends on the extent of implementation.

This article addresses the role of formal, informal, and automated controls as they relate to the relationship between EDI implementation and performance. This causal model will help explain the contribution of three EDI controls to system performance during the operation stage. A research model for EDI controls is proposed based on EDI implementation and control literature. This model was empirically tested with data collected from Korean companies that have adopted EDI. A summary of empirical findings, implications for practice, and future research issues are included.

EDI Implementation and Performance

The "extent of EDI implementation" indicates the extent to which EDI is used and spread throughout an organization. The positive effects of EDI implementation on performance have been consistently proven. Integration of information collected through EDI with internal IS applications has been asserted to be a critical factor for system effectiveness and efficiency [11, 18, 21, 30, 31]. Internal applications such as account payable and receivable, and production planning systems may be efficiently processed in conjunction with an EDI system. To compress cycle time and improve data integrity for the rapid transmission of data, The supplier's computer must be integrated with the customer's.

EDI must be extensively utilized in order to reap the full benefits of its integration. Utilization of EDI refers to the extent to which an organization handles its business transactions through EDI. The adoption and implementation of EDI may impose significant one-time costs on an organization as its internal systems are adjusted in order to permit interface with trading partners. Transaction volume should be large enough to cover the initial high investment cost by reducing administrative costs. The goal of many EDI adopters is to replace paper documents and verbal-based communication methods, thus reducing order cost and cycle time. These factors cannot be replaced or reduced without substantial shift in the use of the system.

Hypothesis 1-1: The higher the level of EDI integration, the

greater the EDI performance.
Hypothesis 1-2: The higher the level of EDI utilization, the greater the EDI performance.

Modes of EDI Controls

In this study, EDI controls focus on the objectives of safeguarding assets and data integrity in order to reduce the scope of these controls. This paper views EDI controls from a behavioral viewpoint; that is, attempts to ensure that the organizational members developing and operating EDI system act according to an agreed- upon strategy in order to achieve the desired objectives of system security and integrity.

EDI controls are classified into three categories, formal, informal, and automated controls [14]. Formal mechanisms include the rules, regulations, and hierarchy of authority that are used to direct behavior and assess performance. Formal controls are initiated by management rather than lower level employees, and are based on written procedures. The concept of informal controls is based on several previous studies, including that of Jaworski et al. [12]. Informal controls are based on the beliefs and values shared by members of an organization. They are initiated by organization members using the members' values, judgments, and communications. Automated controls indicate automated control procedures and methods. It is difficult to manually ensure the integrity of EDI messages when large volumes of data and various types of documents are sent to diverse trading partners.

Formal Controls and EDI Performance

EDI requires standardized transaction procedures and industrial standards to be used [27]. Formal control procedures such as standards, operational procedures, and formal contracts -- including legal issues between trading partners and the VAN -- are essential elements of any EDI system. Companies with highly standardized processes are better prepared to undertake integrated EDI projects. The implementation of EDI in such an environment helps to increase the impact of the technology and provide greater benefits.

The requirement of formal guidelines, however, may not be as great for companies with a low degree of implementation. As the institution and enforcement of these rules requires appropriate IS resources such as internal auditors, such guidelines should be assessed from a cost-effectiveness viewpoint. When a high volume of transactions must be processed quickly EDI greatly enhances the speed, accuracy, and completeness of communications between partners by formalizing the communication process and procedures [25].

Formal controls are particularly important to efficient system performance during external expansion of EDI. Mutual reliance between trading partners, if not well founded in factual and objective reality, may lead to critical risk (e.g., legal dispute) in EDI systems. Increased reliability of information is prerequisite to the reinforcement of ties with a particular business partner, and must be assured through provisions requiring trading partners to establish the integrity of their EDI records. This assurance requires procedures for detecting and acknowledging errors and failures in their messages. Customer service improves by avoiding paper manipulation and data re-entry by the recipient. The extent of this improvement depends on the extent of usage of standardized procedures and data integrity controls in the communication process.

Hypothesis 2-1: The impact of integration on EDI performance is greater when the usage level of formal controls is higher.
Hypothesis 2-2: The impact of utilization on EDI performance is greater when the usage level of formal controls is higher.

Informal Controls and EDI Performance

Informal controls are implemented by propagating common beliefs and social norms within a group of individuals. The socialization process of identifying "acceptable behaviors" among members of the EDI staff reinforces informal controls (e.g., awareness, commitment, responsibility). The intrinsic motivation, experience, and knowledge of EDI staff members, which are enhanced by communication with their colleagues or counterparts in trading partners may greatly affect the "socialization" process of EDI staff members; this enables them to define their own goals and processes for their tasks. When an organization uses EDI with its trading partners, both parties depend on informal controls (e.g., use of experience, knowledge, and communication), for system efficiency and effectiveness.

Moral commitment from EDI staff members is highly crucial in order to manage sophisticated systems and reduce expected risk from unauthorized and inadvertent destruction of assets; it also maintains data integrity, and ensures that data is accurate and complete. If employees' sense of responsibility is heightened, they will be less likely to try to abuse the system. A commitment from organizational members can highlight the possibility of system abuse and prevent system performance from being degraded due to computer abuse.

Informal controls are enhanced through the experience of organizational members. This employee experience of employees helps reduce the complexity of innovation, i.e. the degree to which an innovation is perceived as difficult to understand and use [19, p.230]. The ability to effectively use the system influences the level of satisfaction. When EDI adopters lack technical expertise, experience can compensate for this shortcoming by enabling them to seek procedures which will improve system performance.

Personal motivation toward the security and integrity of the system is enhanced through its perceived benefits by organizational members. These perceived benefits may in turn be affected by the communicability of a particular innovation which can be improved by interaction and communication among EDI staff members. The lack of information about EDI technology is a problem not only in EDI implementation but also in its operation. This makes it

difficult for staff members to cope with routine or unexpected problems in their jobs. They need support from their colleagues to correct errors and failures in the system.

Hypothesis 3-1: The impact of integration on EDI performance is greater when the usage level of informal controls is higher.
Hypothesis 3-2: The impact of utilization on EDI performance is greater when the usage level of informal controls is higher.

Automated Controls and EDI Performance

The controls required for an on-line system differ from those for a batch system. The higher volume and speed of data processing are characteristic of integrated EDI systems. These characteristics increase the need for appropriate and timely error resolution through the use of programmed access controls, real-time feedback of integrity check, and rapid recovery system. EDI is an automated communication system without human intervention. Controls should migrate from management by humans to management by computerized programs integrated with internal applications and linked with external partners [1, 6, 8, 10, 17, 32]

When large volumes of data are processed at a high speeds through EDI, the benefits of automated controls may exceed their costs [7, 16]. If automated controls are installed to manage the interface between application systems and EDI networks, the EDI system can promptly detect and correct errors in data instantly after transactions are received and immediately before messages are sent. Messages can be altered or lost as a result of disruptions in internal data processing. Automated controls protect internal application systems from the errors made in external network instantly. As the integration and utilization of EDI advances, the system needs embedded automated controls which detect and correct errors in order for EDI to function well.

Hypothesis 4-1: The impact of integration on EDI performance is greater when the usage level of automated controls is higher.
Hypothesis 4-2: The impact of utilization on EDI performance is greater when the usage level of automated controls is higher.

Research Data

The survey instrument was initially pretested with 10 EDI practitioners. The wording, interpretation of items, and the extent to which practitioners felt they possessed the knowledge necessary to provide appropriate responses was analyzed in the pilot test. After the interview with practitioners, the questionnaire was gradually modified. A final review was made by four IS professors.

Respondents include organizations from diverse industries, as companies in different industries develop EDI for their own purposes. The respondent organizations were selected from various industries in order to show the diverse state and the alternate forms of controls. The selected respondents were thought to possess the level of knowledge about EDI controls required to answer the questionnaire. Eight companies refused to participate in the interview; some feared exposure of their system vulnerabilities. A comparative analysis of industry membership and revenues was conducted in order to determine whether responding firms had significantly different characteristics from nonrespondents. No significant differences were found; thus, response bias was not a concern in this study.

Data were collected using structured interviews with EDI practitioners. The mail survey method was avoided because of the difficulty in obtaining reliable responses from the questionnaire, which addressed such sensitive and confidential issues as IS security and controls. The data used in validating the research model were gathered as part of a larger investigation concerning EDI controls [14]. Using the structured questionnaire, a total of 110 interviews were conducted; respondents were EDI staff members or managers.

Table 1 shows descriptive statistics of company size. The average number of employees in the responding organizations was 5,849. Larger firms were more easily able to invest resources to integrate and control EDI than were small firms. Therefore, EDI user firms were expected to be larger firms.

Table 1: Respondent Profiles

	Mean	Median
Number of employees in organization	5849	2076
Annual Sales (billion won)	1953	610
Number of Employees in DP dept.	86	40

Measurement Reliability, and Validity

Questionnaire items about formal, informal, and automated controls were based on the studies on EDI controls by Lee et al. [14]. Items for formal controls assess the usage level of formal application and communication controls. Informal controls have the following components: risk recognition and sense of responsibility, experience, and interaction among the members of the EDI staff. Automated controls were measured with automated control procedures and methods. Automated controls are composed of two components, programmed integrity checks and security and authentication software.

Measures for Integration and utilization were adapted from Premkumar et al.'s [18]. They were measured by the integration and utilization of five application systems closely connected with EDI that were selected by respondents. Examples of applications can be categorized as trade, retail, transportation and banking.

Integration was defined as the extent to which data can be directly entered into internal applications without additional preprocessing. Integration was measured on a seven-point Likert-type scales. Utilization was measured as the proportion of a firm's information exchange and processing handled through EDI.

The measure for performance was based on various EDI survey results [4, 5, 10]. Reinforcement of ties with a business partner, improved customer service, cost reduction and increased reliability of information were the most important benefits reported by the majority of respondents. EDI performance is measured using eight items: improvement of relationship by reduced response time (PERF-1), improvement of relationship by reduced delay from errors (PERF-2), improvement of trust by enhanced confidentiality of documents (PERF-3), improvement of 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).

A reliability analysis was conducted and items with low-to-total correlations were deleted. The final Cronbach's alphas for controls are shown in Table 2 (see diagonal entries). Diagonal entries indicate reliability estimates of coefficient alpha. The Cronbach alphas for the formal, informal, and automated controls, EDI performance are 0.8240, 0.9070, 0.7517, 0.9278. All scales exceeded 0.7 after low-to-total correlated items were deleted. The analysis of reliabilities indicates the measures are internally consistent and reasonably free of measurement error.

Table 2: Cronbach's alphas and zero-order correlations (*** p < 0.01, ** p < 0.05, * p < 0.1)

	Cronbach's alpha	formal controls	informal controls	automated controls	integration	utilization	performance
formal controls	.8240	1.0000					
informal controls	.9070	.5758*** p=.000	1.0000				
automated controls	.7517	.5464*** .000	.6818*** .000	1.0000			
integration	—	.2753*** p=.002	.2338*** p=.007	.2778*** p=.002	1.0000		
utilization	—	.2326*** p=.009	.2432** p=.013	.1353* p=.086	.3212 p=.001***	1.0000	
performance	.9278	.5058*** p=.000	.4858*** p=.000	.4219*** p=.000	.3898*** p=.000	.2826*** p=.002	1.0000

Construct validity was assessed using convergent and discriminant validity. The test of convergent validity was performed using principal component analysis. Items for each variable were individually factor analyzed to preserve the structure of the theoretically-derived variables. For each construct, only one factor emerged, which shows their unidimensionality. All variables have one factor. Thus, there is sufficient theoretical justification to consider control and performance measure as single constructs.

A test of discriminant validity was performed by comparing correlations among variables with Cronbach alpha. Gaski and Nevin [9] have suggested that if the correlation between two variables is less than each variable's coefficient alpha, it indicates a good discrimination (see also [2]). The results in Table 2 show satisfactory discrimination among variables, since the correlations between the different constructs are in no case as high as the coefficient alpha of individual construct. For example, coefficient alpha of informal controls, 0.9070, is greater than any correlations between informal controls and other variables, which range from 0.2326 to 0.5798.

The reliabilities, factor analysis and correlations analysis show strong evidence for the construct validity of the EDI controls, implementation, and performance scale. Hence, these measures are appropriate operational definitions of the constructs they purport to measure.

Data Analysis and Results

The first analysis tested the hypothesis predicting the relationship between implementation and performance. The regression equation has implementation (integration and utilization) as independent variables. In the first regression equation (see Table 3), the direct effect of integration (hypothesis 1-1) is significant while that of utilization (hypothesis 1-2) is not. This indicates that integration is the only important determinant of EDI performance. Performance depends more on the extent of integration than on the extent of utilization. This result further suggests that integration is more beneficial to EDI adopters than is expansion of system usage. EDI adopters must expand their connections with trading partners in order to increase utilization; this in turn demands substantial support from trading partners. As more influential trading partners in the industry implement EDI, other firms in the same industry will be pressured to implement EDI for fear of losing business or their competitive position. Organizations can reap greater benefits from the implementation of EDI by adopting a proactive than reactive stance [26]. When EDI is reactively implemented from peer pressure from the industry or the requirements of "doing business", the degree of utilization may not enhance EDI performance.

Due to external constraints such as lack of industry standards or technological incompatibility, companies may be discouraged from expanding external systems with trading partners or developing different kinds of EDI messages requiring industry or proprietary standards and technical expertise to overcome compatibility problems. In this case, it is only possible to link a number of partners when they exert some influence on their partners to use

EDI. When external influences affect utilization more than other factors, a firm's trading partners will not recognize the strategic necessity of EDI. This lowers the perceived performance of EDI, despite the high level of utilization.

Table 3: Multiple Regression Results: dependent variable = performance
(*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$) (R^2=.1902, Adjusted R^2=.1740, F =11.7440***)

Independent variables	beta	Standardized beta	T-value	p-value
CONSTANT	2.8671	—	7.058***	.0000
integration	.2972	.3504	3.687***	.0008
utilization	.6090	.1705	1.794	.1516

Multiple regression with product terms is the most common approach for testing interaction effects [29]. However, product terms are highly correlated with component variables. There exists the possibility of multicollinearity producing large standard errors of regression coefficients and unstable equations. For example, the correlation between formal controls × utilization and utilization was 0.9294, and the correlation between formal controls × integration and integration was 0.8166. Hence, cross tabulation of contingent table analysis was used to test the moderating role of EDI controls in the relationship between implementation and performance. Observations were split two groups, a "high group" and a "low group", with the median value as the dividing point. For instance, the cases having a higher value of formal controls than the median value were classified as "high formal control group".

Table 4 summarizes the influence of controls on the relationship between implementation and performance. The moderation hypotheses was tested by the significant χ^2 statistics of the high control group. Results indicate that performance was positively dependent upon integration in the high formal, informal, and automated control groups, while performance did not depend on integration in the low control group. Thus, formal, informal, and automated controls must be high in order to produce high performance in a highly integrated environment (hypothesis, 2-1, 3-1, 4-1). When data are processed in a highly integrated manner with internal applications, rules and regulations established by IS departments, as well as personal values, experience, and recognition may be necessary to increase performance. Automated controls, such as integrated audit routines may also be required for performance in highly integrated environment.

Table 4: Interaction effects of integration and controls on performance
(*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$)

Contingency Factors		performance	Integration		utilization	
			Low	High	Low	High
formal controls	Low	Low	21	10	19	11
		High	10	7	9	8
		χ^2-value	.3818	(p = .5367)	.4866	(p = .4855)
	High	Low	13	11	11	11
		High	7	30	13	22
		χ^2-value	8.2071***	(p = .0042)	.9161	(p = .3385)
informal controls	Low	Low	23	16	23	15
		High	6	8	9	5
		χ^2-value	1.0800	(p = .2987)	.0611	(p = .8048)
	High	Low	11	5	7	7
		High	11	29	13	25
		χ^2-value	8.1529***	(p = .0043)	1.0776	(p = .2992)
automated controls	Low	Low	15	8	13	10
		High	7	3	8	2
		χ^2-value	.0717	(p = .7888)	1.6603	(p = .1976)
	High	Low	19	13	17	12
		High	10	34	14	28
		χ^2-value	10.5442***	(p = .0012)	4.4596**	(p = .0347)

However, only the high automated control group showed a significant relationship (χ^2 = 4.4596, p=.0347) between utilization and performance (hypothesis 4-2). This shows that although high formal and informal controls are required for performance, lack of formal and informal controls can be compensated by using automated controls in a highly utilized environment. The less significant interaction effects of utilization and EDI controls on performance compared with the results for integration appear consistent with the results of the regression analysis which showed a less significant effect of utilization on performance. Because EDI adopters do not perceive additional benefits from the increase of the extent of utilization, the establishment of controls cannot be attractive. Formal written rules do not appear proportionally cost-effective as the extent of utilization (hypothesis 2-2) increases, since the role of VAN service providers or external systems become greater in monitoring communication. As the number of EDI documents and trading partners increases, EDI adopters depend more on communication controls by VANs or "hub" companies than on controls developed by themselves. Firms even choose to replace their own current communication controls with controls provided by VANs, as they are more cost-effective and include additional peripheral services. Companies can concentrate on their own business and reduce the burden of

controls after they allow VANs to perform conversions between different trading partners' environments and support varied protocol and access methods.

The insignificant interaction effect between utilization and informal controls (hypothesis 3-2) showed that the need for personal experience and recognition do not proportionally increase as the scope of EDI tasks are expanded. Increasing utilization seems to demand no additional commitment or sense of responsibility from the adopting companies as they rely on VANs and trading partners to control external connections. However, when EDI is highly utilized, automated controls are important for performance as it becomes necessary to check the different standards or formats of messages directed towards to themselves and diverse trading partners.

Conclusions and Implications

The primary theme is that EDI controls affect the relationship between implementation and EDI performance; the evaluation of EDI controls is important to ensure high system performance. This study explains why some companies have higher performance than others that are in the same or different stages of implementation. It was shown that integration and utilization of EDI affect system performance. When EDI is highly integrated, formal, informal, and automated controls must be enhanced in order to provide high performance. However, high utilization ultimately affect performance only when the usage level of automated controls is high.

The results of this study have significant implications for EDI practitioners. EDI should be fully implemented to allow significant performance. The true potential of EDI is achieved only when it is integrated with internal applications and linked with many trading partners who communicate via diverse EDI documents. However, companies that intend to further integrate and expand EDI use must decide whether their current state of EDI implementation is producing satisfactory performance. Reductions in cycle time or administration cost may not be sufficient to offset the cost of implementation.

IS managers may persist in considering their organizations safe from various threats and be unfamiliar with laws concerning computer crimes [15]. This is much more the case in Korea, although the system is rapidly being connected with external networks. Although respondents seem to be well aware of such threats, they believe that their employees and trading partners operate in good faith and seem to believe that bad things only happen to other people.

In this context, this empirical evidence of the moderating role of EDI controls on performance should encourage EDI practitioners to invest IS resources to enhance controls. The high risk of mishaps and errors makes the system unreliable and unstable; thus, EDI adopters must design control systems. They have to enhance the security and integrity of the data and programs to provide accurate information and immediate response. If EDI performance level is unsatisfactory, formal, informal, and automated controls should be checked and adjusted.

The key issue is optimizing investment in controls, because the effectiveness of EDI controls depends on the extent of EDI implementation. EDI adopters must address whether their existing investment in EDI controls makes sense, given the current and future extent of the integration and utilization of EDI. The benefits from the implementation of EDI controls are contingent upon adequate attention to the extent of integration and utilization that the company plans. Having understood the relative risks and benefits of EDI control design, EDI adopters must determine if the additional risk from the integration and utilization of EDI is acceptable given the associated benefits from a risk management perspective. By adopting a diversified control portfolio of three modes of controls, companies can align their control design with the integration and utilization while maintaining low risk exposure.

Management may place high authority on the security department to be proactive in formally establishing formal security procedures during system development. EDI managers and auditors should decide which subsystems are most vulnerable. Greater internal auditing resources should be invested for the development of formal controls in the most vulnerable subsystems.

Formal procedures include education and training programs that increase the sense of risk and responsibility and expedite informal interaction among employees. As it often takes time for organizational members to experience various operational problems, management may need to provide consistent and periodic training programs. In addition to these programs, management should emphasize the severity of punishment and increase the effects of deterrents against possible abuse. The fact that computer abusers will be punished according to the damage of abuse can be communicated in seminars, workshops, and in other settings. Because there is a greater possibility of inadvertent system errors or computer abuse by less motivated offenders, the awareness of severe penalties for security violations can effectively deter illicit behaviors which bear the risk of heavy penalties.

Management should consider the implementation of security software and introduction of specialized control techniques such as concurrent audits, continuous and intermittent simulations (CIS), and parallel simulations to audit batch processing where needed in view of the extent of integration and utilization of the EDI system. Technical expertise and adequate IS budget are necessary for the successful implementation of automated controls. It will be difficult to invest IS resources to implement automated controls in subsystems if their sensitivity and vulnerability to risks is low. Hence, the efforts are needed to assess the risk to the system and to analyze the cost-effectiveness of controls before investing. The timeliness and accuracy requirement of systems should be considered in the decision of investment for automated controls [14]. The automation of controls needs to be higher when time delay for the functioning of controls or minor errors in value or quantity of transactions cannot be allowed, such as in the JIT banking system.

The arrival of the commercial use of the Internet, driven by its World Wide Web (WWW) subset, has been defining

internet-based EDI. The Internet has begun to receive attention as a cost-effective channel for EDI transactions because of its potential for facilitating the entry of more companies in such networks, both by: reducing setup costs; providing readily available ubiquitous access with few geographical constraints; making it feasible to interconnect a vast range of business applications [22, 23]. The *flat-pricing* that is independent of the amount of information transferred makes the Internet a cheaper medium than the standard VAN approach of charges per character. Converting new users to Internet EDI is relatively rapid when World Wide Web, which provides on-line templates for transaction details, is used for the initiation of transactions. As an increasing number of firms consider moving their EDI transactions to the Internet, many VANs have begun to offer internet-based EDI service [13].

Telecommunications networks, protocol technology (e.g., Simple Mail Transport Protocol (SMTP) for Internet-based EDI), transmission media (e.g., coaxial cable and fiber optic)) are the foundation of an internet-based EDI system. It would be entirely wrong, however, to consider electronic commerce as a purely technological issue [33]. It is premature to believe that a significant portion of EDI traffic will soon travel over the Internet, because of the many business issues to be resolved. One such problem is the security and reliability of the Internet (e.g., [3], [28]). Because of these security concerns, the Internet might not always be the cheaper alternative medium for EDI transactions.

The framework of formal, informal, and automated controls remains important in the Internet-based EDI. The Internet can be used directly for exchanging EDI transactions bypassing VANs. Nevertheless, trading partners still have to reach some agreement on trade procedures (e.g., protocol, format of messages, acknowledgements). Porting EDI to the Internet demands additional procedures to insure security and integrity, especially for companies that require high levels of security (e.g., government agencies, research institutes, banks) [20]. Internet-EDI must also offer secure procedures (i.e., formal controls) through which secure business transactions can occur, while remaining open to easy communication between all parties involved in electronic commerce. Awareness of responsibility and commitment of internal users (i.e., informal controls) is becoming more important as the possibility of compromising existing security controls increases. Finally, automated controls based on authentication and encryption technologies (i.e., automated controls), digital signatures, and firewalls [20] are important and the network security market is responding quickly to security threats by providing to the Internet new products related to these technologies. Consequently, the unprecedented growth in Internet use and the increasing movement of EDI away from its traditional base onto the Internet still demands formal, informal, and automated controls for its successful use.

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