Analyzing contextual antecedents for the stage-based diffusion of electronic supply chain management

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**Abstract**

This paper proposes a theoretical model for understanding the fundamentals of the diffusion of electronic supply chain management with multiple stages among trading partners. It also provides an empirical analysis of a framework that helps us to gauge the practical validity of our approach. We considered two control variables, industry type and firm size, and their effects on e-SCM diffusion. We developed our measurement approach on the basis of existing theory. We gathered data using a structured questionnaire that was administered through e-mail. The findings that we obtained reveal that the attributes for technological and collaborative structures have different impacts on the three diffusion stages. Overall, technological structure is a more important indicator for the adoption stage, while collaborative structure is more important in the assimilation stage. This is because the focus of innovation diffusion at the earlier stages is on the improvement of perceived usefulness, ease of use, and information security. Innovation diffusion at the later stages mainly lies in building good cooperative relationships among trading partners to facilitate their transactions. Industry type and firm size are correlated to different degrees with the attributes of technological and collaborative structures, and with the different diffusion stages.

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1. Introduction

In the contemporary environment, competition is no longer between organizations, but between supply chain partners. Business organizations are increasingly thinking that they must compete, as part of a supply chain against other supply chains, to rapidly reflect customers' changing demands (Cigolini et al. 2004). The supply chain process, in essence, is complex and dynamic across a large number of trading partners. To respond to these challenges, supply chain management (SCM) is an important concept to effectively help firms to manage their partners so that they can further build long-term partnerships (van der Zee and van der Vorst 2005). SCM can be extensively defined as: effective coordinations on material, subassembly, product, delivery, and payment flows between enterprise and trading partners (Ruppel 2004, van der Zee and van der Vorst 2005, Lin and Lin 2006). Effective flow management across inter-organizational boundaries is the major focus of SCM concept. Information technology (IT), such as Internet and communication technology, is therefore an important tool to make the deployment feasible (Lin and Lin 2006). For example, supply chain partners need to share production information to rapidly and accurately respond to inventory demand.

For these reasons, SCM has been widely recognized as a significant area for IT investments to support its processes (Byrd and Davidson 2003). Electronic SCM (e-SCM) is therefore defined as the physical implementation of SCM process with the support of IT while also making a distinction from the general management concept of SCM. However, e-SCM, although still considered to be in its early stages and with a high reported failure rate, is nonetheless believed to be the key to the final success of SCM process (Patterson et al. 2004). Because of this trend, the IT innovation issue is the crux of modern SCM research. Nevertheless, past research has simply focused on a single decision view of adoption/acceptance for its deployment based on theories such as the technology acceptance model (TAM), theory of planned behavior (TPB) and their extensions (Davis et al. 1989, Ajzen 1991). More specifically, innovation diffusion theory (IDT) is a theory to understand the diffusion of an innovation across time (Rogers 1995, 2003). Based on IDT, researchers have presented some models specifically for information systems (IS) innovation. These models were often addressed as a stage-based process, such as a three-stage model with initiation, adoption, and implementation (Zmud 1982, Grover and Goslar 1993) or a six-stage model with initiation, adoption, adaptation, acceptance, routinization, and infusion (Kwon and Zmud 1987, Cooper and Zmud 1990). Accordingly, a stage-based diffusion
analysis would provide insight for understanding e-SCM implementation problems (Swanson and Ramiller 2004).

Moreover, because this diffusion process is dynamic and complex in nature, analyzing this process requires an understanding of the fundamentals of the evolutionary changes across time. According to innovation researchers, a variety of contextual factors, which were clearly discussed in IDT, may affect an organization's decision to diffuse new technologies (Rogers 1995). Furthermore, Kwon and Zmud (1987) have proposed a model with five contextual factors in impacting IS innovation diffusion, including innovation (new technology), task, individual, organization, and environment. In general, these five factors can be further classified as technological and non-technological structures. The non-technical structure consists of four relevant factors, task, individual, organization, and environment. The technological structure is defined to include one factor, innovation. e-SCM diffusion basically involves both internal diffusion among functional units within an organization and external diffusion across a large number of inter-organizational trading partners. This research was mainly focused on examining the aspect of the external diffusion of e-SCM across trading partners. Technological and environmental factors were therefore the major concerns in this research (Rajagopal 2002, Ranganathan et al. 2004). In contrast, task, individual, and organizational factors intended to focus on the aspect of the internal diffusion and would not be considered in this research. Some researchers have also differentiated between intra-organizational and inter-organizational factors in understanding their different impacts on IOS diffusion (Premkumar and Ramamurthy 1995, Ramamurthy et al. 1999, Patterson et al. 2003, Ranganathan et al. 2004).

Furthermore, e-SCM diffusion has been considered to be an open collaborative system among trading partners, and the literature has greatly emphasized the particular collaborative relationships in e-SCM diffusion rather than the general external environment in IS diffusion (Kumar and van Dissel 1996, Ramamurthy et al. 1999, Ranganathan et al. 2004, Ruppel 2004, Russell and Hoag 2004). Collaborative relationships between participants mainly concern the degrees of communication, trust, and interdependence, which result in creating more stable transactions and reducing certain levels of uncertainty and risk in the market (Kumar and van Dissel 1996, Smith et al. 2007). Accordingly, collaborative relationships are defined as consisting of a composition of relevant relationship attributes. We defined it as the collaborative structure in this study. Next, in IOS research, attributes of supply chain technologies are often defined in terms of the characteristics of innovation factor, as discussed in Rogers (1995, 2003). We defined it as the technological structure. More specifically, technological structure includes three attributes: relative advantage, complexity, and ability to provide security; and collaborative structure comprises four attributes: peer pressure, transaction climate, environmental uncertainty, and supplier interdependence. Next, a comprehensive literature review was initially carried out to theoretically define the stage-based structure to include three stages, adoption, implementation, and assimilation. This diffusion structure will be further confirmed by empirical data for the latter analysis. These three components will be described in detail in the next section. In addition, many studies on the issue of organizational innovation have suggested the moderating roles of some organizational characteristics, such as industry type and firm size, on the realization of firm performance (Rogers 2003, Teo et al. 2003, Subramani 2004, Banker et al. 2006). We specified industry type and firm size as two moderating variables.

Accordingly, this study proposed a research model for understanding the relationships between the two structures, technology and collaboration, and a stage-based e-SCM diffusion while also indicating the moderating roles of industry type and firm size on their relationships. This research has made contributions in many aspects. Most studies on the diffusion of inter-organizational systems (IOS) have been focused on two organization-related factors, intra-organization and inter-organization (Premkumar and Ramamurthy 1995, Ramamurthy et al. 1999, Patterson et al. 2003, Ranganathan et al. 2004). This research has comprehensively considered two important but relatively distinct factors, technology and collaboration. The technological factor has been well recognized as the major enabler of innovation diffusion (Davis et al. 1989, Rogers 1995, Hernandez et al. 2008, Kim et al. 2009, Lee and Park 2008). The stage-based diffusion structure has been often considered as two stages, internal diffusion and external diffusion (Premkumar et al. 1994, Ramamurthy et al. 1999, Ranganathan et al. 2004). An important diffusion stage, adoption, which initiates the decision of investing new innovation and prepares for business process redesign, has been usually ignored in prior research (Cooper and Zmud 1990, Rogers 1995, Wu 2002, Swanson and Ramiller 2004). The paper is organized as follows: Section 2 reviews the literature and then develops hypotheses; Section 3 includes instrumentation design, sample design, and scale validation; Section 4 presents statistical analysis and hypotheses testing; Section 5 discusses the main findings; Section 6 indicates conclusions.

2. Literature review and hypotheses development

Based on the above discussion, Fig. 1 provides a pictorial depiction of this research framework. The following paragraphs discuss the theoretical foundation of this framework and development of hypotheses.

2.1. SCM and e-SCM

Most firms are striving to improve their flexibility and customer responsiveness in the dynamic market. The concept of SCM is an important weapon for them to reach the goal (Gunasekaran et al. 2001, Tan et al. 2002, Gunasekaran and Ngai 2004). Moreover, the growth in B2B commerce has spotlighted the role of SCM in the modern digital economy. SCM can be defined as an integration of key business processes from end users through original suppliers for effectively providing various forms of products in the value creation and hence adds value to customers and other stakeholders (Lambert et al. 1998). The mechanism generally involves collaboration, cooperation, and integration activities across an organization and throughout the whole supply chain (Premkumar 2000, Stank et al. 2001). While it is extremely difficult to simultaneously manage these complex activities among trading partners, building strategic relationships with them is thus the ultimate goal of SCM. Basically, there are three major flows through the supply chain: product/service, payment, and information (Premkumar 2000). These flows require a constant and substantial amount of interactive online communication and collaboration among trading partners.

Without the support of IT, in particular, Internet and communication technologies, the goal of SCM would not be effectively accomplished (Byrd and Davidson 2003, Patterson et al. 2003, Russell and Hoag 2004). e-SCM is therefore defined for the purpose of IT-enabled support in implementing SCM process. Past research has revealed that IT is an effective tool to provide an electronic linkage infrastructure to facilitate the movement of the three flows in the supply chain (Lee et al. 1997, Stank et al. 1999, Premkumar 2000). In general, supply chain technology includes three components: (1) communication level – used for electronic communication of messages between trading partners, for example, electronic data interchange (EDI), (2) coordination level – focused on the sharing of supply chain information, for example, vendor managed inventory (VMI), and (3) cooperation level – focused on
sharing their common goals and linking their business processes, for example, electronic commerce (EC). However, there are many technological and organization-related barriers to the deployment of e-SCM across trading partners (Patterson et al. 2003). Thus, understanding e-SCM diffusion from both aspects will provide insight for overcoming the obstacles.

2.2. IDT and contextual structures

According to Damanpour’s paper (1991), innovation diffusion is defined as “…adoption of an internally generated or purchased device, system, policy, program, process, product, or service that is new to the adopting organization.” IS innovation may be broadly defined as innovation in the organizational application of IT (Swanson 1994). IDT is defined as “the process by which an innovation is communicated through certain channels over time among the members of a social system” (Rogers 1995, 2003). Although the theory has been originally applied to a range of organizational innovations, much research has been particularly undertaken for exploring IS innovations. Furthermore, the diffusion of IS innovation plays a critical role in determining its use of success (Grover et al. 1998, Gallivan 2001). Basically, two types of research approaches were used to investigate the diffusion of IS innovation: factor research and stage research (Prescott and Conger 1995, Rogers 1995). Factor research generally employs cross-sectional research designs and is used for identifying variables/factors that are related to particular implementation outcomes. Stage research generally uses longitudinal or repeated measures to explore how the diffusion process with multiple stages is guided and affected by changes in related variables over time.

While much innovation research with IDT was mainly based on intra-organizational context, little research has focused on inter-organizational context, for example, e-SCM diffusion. A brief review of relevant literature for the major determinants of inter-organizational diffusion is presented as below. First, several studies for examining the adoption of various supply chain tools have reported many factors that affect their adoption and use. These factors are divided into those related to IT attributes and those related to maintaining the relationships that are important in managing supply chain linkage (Ramamurthy et al. 1999, Ruppel 2004, Russell and Hoag 2004). Next, other studies have examined the diffusion of web technologies or EDI with the impact of internal and external drivers and further, the realization of SCM performance (Rajagopal 2002, Ranganathan et al. 2004). Their results revealed that IT attributes and supplier interdependences are the major factors in affecting this diffusion. In summary, the above studies have clearly indicated a similar argument that the success of diffusing inter-organizational systems is mainly dependent on two key external factors: IT attributes and collaborative relationships. In this study, we named IT attributes and collaborative relationships as the technological and collaborative structures, respectively, for the purpose of consistence and easy contrast between using the two terms. The following subsections further elaborate these two structures.

2.2.1. Technological structure

As discussed previously, technological structure is mainly defined according to the innovation factor discussed in Rogers (1995, 2003). The innovation factor basically includes five attributes: relative advantage, complexity, compatibility, trialability, and observability. According to a comprehensive literature review of IS innovation adoption, we considered two attributes, relative advantage and complexity, which are commonly recognized as the most important drivers in e-SCM diffusion. Relative advantage reflects the degree to which an innovation is perceived as providing better organizational advantages than either the status quo or its precursor. Complexity is the degree to which an innovation is perceived as being difficult to understand and use. Compatibility refers to the degree to which an innovation is perceived as being consistent with the existing norms, experiences, and practices (Rogers 1995, 2003). The reasons behind this consideration are twofold. First, although the five innovation attributes were originally defined in Rogers (1995, 2003), most of the later studies, including both IS innovation in general and IOS in particular, has emphasized the impact of the three attributes, that is, relative advantage,
complexity, and compatibility (Tornatzky and Klein 1982, Premkumar et al. 1994, Russell and Hoag 2004, Al-Qirim 2007, Yu and Tao 2009). One of the studies has investigated the relationships between innovation attributes and innovation adoption with a review and meta-analysis of seventy five articles and has concluded three attributes, relative advantage, complexity, and compatibility, with positive relationships to innovation adoption (Tornatzky and Klein 1982). Second, technology acceptance model (TAM) is an important theory in explaining the acceptance of IS innovation from the perspective of technology (Davis 1989, Davis et al. 1989, Venkatesh et al. 2003, Zhu et al. 2006, Hernandez et al. 2008, Kim et al. 2009, Lee and Park 2008, Yu and Tao 2009). This theory considers two key drivers in determining use of IS innovation, that is, perceived usefulness (PU) and perceived ease of use (PEOU). PU and PEOU in TAM are equivalent to the attributes of relative advantage and complexity, respectively (Moore and Benbasat 1991).

More importantly, recent research for Internet-based innovation, such as B2B e-marketplace and e-commerce, has well focused on the consideration of two innovation attributes, relative advantage and complexity (Zhu et al. 2006, Kim et al. 2009, Lee and Park 2008, Yu and Tao 2009). Their arguments for this consideration are as follows. For Internet-based technologies with open access and common experience to all users, such as supply chain technology and e-commerce rather than EDI, compatibility has been becoming congruent with existing experiences and practices among trading partners and was suggested to be neglected in relevant research or grouped into the attribute of PEOU (Zhu et al. 2006, Yu and Tao 2009). In addition, while e-SCM deployment is primarily driven by the support of Internet and communication technologies, the guarantee of the security of information flow is the important concern in the adoption decision among the trading partners. Thus, the ability to provide security is critically relevant to the further adoption of e-SCM diffusion (Ruppel 2004, Smith et al. 2007). In summary, technological structure was defined to include three major drivers for e-SCM diffusion: relative advantage, complexity, and ability to provide security.

2.2.2. Collaborative structure

Many studies have investigated the importance of collaboration process across supply chain partners (Kumar and van Dissel 1996, Smith et al. 2007). They argued that the central principle in creating flexible supply chain is the essence of collaborative relationships, which can facilitate a mutual decision-making process directed toward achieving common goals across their partners. The term “collaborative relationships” implies the fact that a certain level of communication, trust, and interdependence of firms in their transactions of various supplies has resulted in a reduced level of uncertainty and risk in the market (Kumar and van Dissel 1996). A good collaborative relationship allows trading partners to jointly have a clearer understanding of future demand, develop feasible plans to fit the demand, and coordinate relevant activities to achieve the plans in an efficient and effective manner (Smith et al. 2007). Much research has attempted to identify prerequisites for collaborative relationships in terms of the need of information sharing and integration in supply chains (Mentzer et al. 2000a,b; Barratt and Oliveira 2001). Accordingly, collaborative relationships, in essence, are a combination structure with comprising relevant relationship attributes. We termed it as “collaborative structure” in this study. Accordingly, this structure was defined to explain externally relevant attributes in facilitating a high level of communication among supply chain partners. The following discusses the important collaborative attributes for measuring this structure, including peer pressure, transaction climate, environmental uncertainty, and supplier interdependence.

According to Porter’s five-force competitive model (1980), competitive pressure (one of the five forces) was found to be an important external driver for initiating the deployment of IOS among trading partners (Riggins and Mukhopadhyay 1994, Iacovou et al. 1995, van der Zee and van der Vorst 2005, Al-Qirim 2007). Sawhney and Parikh (2001) particularly argued that the value of B2B supplier networks is a function of the pressure from competitors for participating partners. Researchers have highlighted the external role of competitive pressure in the diffusion of EDI (Premkumar and Ramamurthy 1995, Premkumar et al. 1997, Power and Simon 2004). Accordingly, peer pressure was considered to be one of the important attributes of collaborative structure in the diffusion of e-SCM. Next, another important attribute of collaborative structure is a favorable transaction climate between partners since the climate indicates a high level of trust and commitment partnership (Nidumolu 1989, Premkumar and Ramamurthy 1995, Patterson et al. 2003). A high level of trust and cooperation is required since there are no boundaries for the future transactions among interfirm participants while most of the manual control mechanisms and paper trail, which currently exist to keep the accuracy and integrity of various transactions, will be eventually removed. As a result, a good transaction climate with mutual trust and commitment between partners may play a critical role in facilitating the diffusion of e-SCM diffusion.

Moreover, environmental uncertainty, including unpredictable change in the market and short product life cycle, calls for the need for more accurate, faster information. While SCM aims at building a mutual understanding and trust of partnership for purchase and sale of various materials and components, the partnership is definitely in a position to reduce uncertainty for the unexpected change of material and component supply market (Truman 2000, Patterson et al. 2003). Moreover, researchers have argued that the firms facing environmental uncertainty have a greater incentive to adopt IOS for improving information exchange and reducing uncertainty between trading partners (Ahmad and Schroeder 2001, Patterson et al. 2003). In addition, the resource-dependency theory defines dependence based on an organization’s ability to gain access to resources by establishing relationships with other organizations (Preffer and Salanick 1978). Finally, SCM emphasizes the building of power relationship and interdependence between organizations and other entities in the environment that affects their managerial processes and activities (Power and Simon 2004, Ranganathan et al. 2004). Some studies have indicated that supplier interdependence may play an important role in the formation of supply chain partnerships. While inter-organizational systems, such as e-SCM and B2B commerce, are primarily in building electronic partnerships across trading partners, supplier interdependence is more likely to be important in influencing the potential participants to adopt IOS (Hart and Saunders 1998, Chatfield and Yetton 2000, Ranganathan et al. 2004).

2.3. IDT and e-SCM diffusion

IS innovation diffusion is complex and dynamic in nature. It may vary with distinct sets of antecedents across time and involves different loci of organizational impact (Prescott and Conger 1995). To better understand IS innovation diffusion problems and how they can be solved, a multi-stage rather than a single-stage analysis provides better insight into this process (Gallivan 2001). The purpose of IDT is primarily to explore how a diffusion process with multiple stages is guided and affected by changes in related variables over time. Rogers (1995, 2003) originally proposed a two-stage model for innovation diffusion, that is, adoption and implementation. The adoption stage includes the activities of knowledge acquisition, persuasion and learning, and adoption decision. The implementation stage describes these activities, preparations of changes to organizations, processes, and technologies necessary for innovation deployment. Furthermore, Meyer and Goes (1988) also defined a
five-stage model for organizational innovation, that is, knowledge awareness, evaluation, adoption, implementation, and expansion.

More specifically, this theory has been widely applied to traditional IS settings while IS resource has increasingly become an important source of a firm’s competitive advantage. Kwon and Zmud (1987) first developed a six-stage model for IS innovation diffusion based on Lewin’s three-stage change model (1952), comprising initiation, adoption, adaptation, acceptance, routinization, and infusion. Later, Rajagopal (2002) applied the six-stage model to understand various contextual factors that influence firms to implement enterprise resource planning systems. Moreover, Swan son and Ramiller (2004) described a four-stage model: comprehension, adoption, implementation, and assimilation, to comprehend a firm’s involvement in IT innovation diffusion. In particular, many researchers have unanimously presented a similar three-stage model for traditional IS innovations. For example, Zmud (1982) defined the three stages as initiation, adoption, and implementation for investigating the diffusion of general software practices; Saga and Zmud (1993) described the three stages of acceptance, routinization, and infusion for IT acceptance as a whole; and Zmud and Apple (1992) described the three stages as earliness of adoption, routinization, and infusion to understand the incorporation of electronic scanners in supermarket chains. One study has examined a two-stage model, adoption and infusion, to find out the interaction of task and technology factors on MRP implementation (Cooper and Zmud 1990).

While the stage-based model has been extensively applied to traditional IS settings, little research has been carried out which specifically concerns IOS or e-SCM diffusion. Premkumar et al. (1994) discussed the diffusion of EDI in terms of three stages, adaptation, internal diffusion, and external diffusion. Some studies have examined the diffusion of web technologies in SCM with two major stages, internal diffusion and external diffusion, for the diffusion between the firm itself and its suppliers (Ramamurthy et al. 1999, Ranganathan et al. 2004). Other studies have claimed three sequential types of implementation outcomes for the decision of adopting EDI, extent of adaptation, internal diffusion, and external connectivity (Premkumar and Ramamurthy 1995). However, prior research on IOS adoption/implementation has restricted itself to a dichotomous measure of task and technology factors on MRP implementation (Cooper and Zmud 1990).

Lewin (1952) proposed a three-stage change model, unfreezing, moving, and refreezing, to describe the phenomenon of a system change with implementing organizational innovation. Hence, while consulting to this change model and other researches (Cooper and Zmud 1990, Premkumar et al. 1994), we found out that the various stage-based frameworks with distinct number of stages inherently follow a similar diffusion pattern. This pattern can be described as below. An initiation/adoption stage, where a decision is made to invest in IS innovation and a preparation is initiated for business processes redesign, is followed by other stages starting with an adaptation/acceptance stage, where the organization begins to learn and adapt to the innovation by trying it out and then their feedbacks are collected for the further improvement of the innovation. After that, subsequent diffusion stages initiating with a routinization/infusion stage capture the experiences of expanded use and finally lead to widespread transfer for regular use in an organization.

Accordingly, a classification scheme proceeds for defining the diffusion stages as follows: (1) adoption classified for initiation, comprehension, earliness of adoption, and adoption; (2) implementation classified for adaptation, acceptance, and implementation; and (3) assimilation classified for routinization, infusion, and assimilation. Moreover, an extended study of IDT with attitude theory, exploring the impact of user belief and attitude on innovation adoption, has found differences between pre-adoption and post-adoption stages (Karahanna et al. 1999). This provides further evidence for rationality of the classification process. Based on the above discussion, we initially proposed a three-stage model to examine e-SCM diffusion, that is, adoption, implementation, and assimilation. Accordingly, we defined adoption stage as the decision for investing e-SCM and the preparation for redesigning SCM processes, implementation stage as the process for trying to use e-SCM and further accepting to use the innovation, and assimilation stage as the process for continuously gaining experiences of using e-SCM and finally leading to regular use of the innovation.

However, previous studies for the diffusion of IOS implied some weaknesses in their stage definition. First, most of these studies emphasized the distinction between the two stages of internal diffusion and external diffusion. However, supply chain alliance associated with trading partners is a closed system with a well-defined boundary as a whole. It is very difficult for practitioners to well distinguish internal diffusion and external diffusion in the diffusion of supply chain technologies. This diffusion between trading partners should be considered in a common and seamless scope without the separation of the firm and its partners, as discussed previously for traditional IS settings. Second, most of IOS studies were lack of discussing the importance of a decision for investing the innovation and a preparation for business process redesign (adoption stage) while only considering the two stages of internal diffusion and external diffusion.

2.4. Hypotheses development

The literature has, so far, focused on a single decision view of adoption or non-adoption for e-SCM diffusion (Patterson et al. 2003, Patterson et al. 2004). Grounding on IDT and relevant e-SCM diffusion studies, a stage-based diffusion approach would provide insight into implementation problems and how they can be solved (Rogers 2003, Swanson and Ramiller 2004). Furthermore,

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<th>Model</th>
<th>Name of stage</th>
<th>Literature</th>
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<td>Adoption, infusion</td>
<td>Cooper and Zmud (1990)</td>
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<td>Three-stage</td>
<td>Internal diffusion, external diffusion</td>
<td>Ramamurthy et al. (1999) and Ranganathan et al. (2004)</td>
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<td>Initiation, adoption, implementation</td>
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<td>Acceptance, routinization, infusion</td>
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<td>Earliness of adoption, routinization, infusion</td>
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<td>Adaptation, internal diffusion, external diffusion</td>
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<td>Four-stage</td>
<td>Extent of adaptation, internal diffusion, external connectivity</td>
<td>Premkumar and Ramamurthy (1995)</td>
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<td>Five-stage</td>
<td>Comprehension, adoption, implementation, assimilation</td>
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<td>Six-stage</td>
<td>Knowledge awareness, evaluation, adoption, implementaion, expansion</td>
<td>Meyer and Goes (1988)</td>
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this diffusion process is dynamic and complex in nature. This requires further understanding of the underlying determinants of the evolution of e-SCM diffusion. In essence, the major concerns of this diffusion focus on the two external aspects, technological and collaborative structures, across trading partners. The above literature has well discussed the two important aspects and their impact on e-SCM diffusion across the various stages. Accordingly, this study integrated innovation diffusion theory and the two contextual structures to explore e-SCM diffusion. The followings develop the relevant hypotheses for this framework.

While realizing the benefits from IOS deployment is the major enabler of the partners, many studies have articulated the difference of relative advantage across various stages of diffusion in IOS settings (Prescott and Conger 1995, Rogers 1995, Stank et al. 1999, Ramamurthy et al. 1999). Thus, we can argue an important linkage between relative advantage and the three stages of e-SCM diffusion. Hypothesis 1 is thus proposed for this. The issue of the impact of complexity on new innovation has been important for the inhibition or adoption of the new innovation. Researchers have investigated the discrepancy of complexity across various stages of diffusion in IS or IOS settings (Karahanna et al. 1999, Ramamurthy et al. 1999, Stank et al. 1999). Thus, we can posit a close relationship between complexity and the three stages of e-SCM diffusion. Hypothesis 2 is thus proposed for this. Some studies have particularly considered the importance of ability to provide security in IOS diffusion and have examined the difference of this attribute across various stages of diffusion in IOS settings (Russell and Hoag 2004, Smith et al. 2007). Thus, we can argue a facilitating linkage between ability to provide security and the three stages of e-SCM diffusion. Hypothesis 3 is thus proposed for this.

Hypothesis 1 (The relative advantage hypothesis). Relative advantage is positively related to e-SCM’s adoption, implementation, and assimilation.

Hypothesis 2 (The complexity hypothesis). Complexity is positively related to e-SCM’s adoption, implementation, and assimilation.

Hypothesis 3 (The security provision hypothesis). Ability to provide security is positively related to e-SCM’s adoption, implementation, and assimilation.

There were a number of the articles in the diffusion of IOS, which have considered competitive pressure as the important drivers for encouraging firms to effectively move across various stages of diffusion (Premkumar and Ramamurthy 1995, Ranganathan et al. 2004). Thus, we can posit an influencing linkage between competitive pressure and the three stages of e-SCM diffusion. Hypothesis 4 is thus proposed for this. Another attribute of collaborative structure is the transaction climate which builds a climate of mutual trust and faith between trading partners and has the important implication in facilitating the diffusion of IOS (Nidumolu 1989, Premkumar and Ramamurthy 1995, Patterson et al. 2003). Thus, we can argue an important relationship between transaction climate and the three stages of e-SCM diffusion. Hypothesis 5 is thus proposed for this.

Hypothesis 4 (The peer pressure hypothesis). Peer pressure is positively related to e-SCM’s adoption, implementation, and assimilation.

Hypothesis 5 (The transaction climate hypothesis). Transaction climate is positively related to e-SCM’s adoption, implementation, and assimilation.

While the major consideration for the firms adopting IOS was strongly attributed to demanding market uncertainty on acquiring abundant materials and components for the purpose of product production, market uncertainty would have the impact on the adoption of e-SCM. Some studies have investigated the difference of environment uncertainty across various stages of diffusion in IOS settings (Kumar and van Dissel 1996, Ahmad and Schroeder 2001, Patterson et al. 2003). Thus, we can argue a facilitating relationship between environment uncertainty and the three stages of e-SCM diffusion. Hypothesis 6 is thus proposed for this. Finally, the interdependence of the firm with its suppliers, which is built on common interest and effective communication, has indicated a critical role in the deployment of IOS. Much of IOS diffusion research has tested the variations across various stages of diffusion in terms of supplier interdependence to provide insight for practitioners (Premkumar and Ramamurthy 1995, Ranganathan et al. 2004, Ruppel 2004). Thus, we can posit an influencing linkage between competitive pressure and the three stages of e-SCM diffusion. Hypothesis 7 is thus proposed for this.

Hypothesis 6 (The environmental uncertainty hypothesis). Environmental uncertainty is positively related to e-SCM’s adoption, implementation, and assimilation.

Hypothesis 7 (The supplier interdependence hypothesis). Supplier interdependence is positively related to e-SCM’s adoption, implementation, and assimilation.

2.5. Control variables

Many studies on organizational innovation suggested a number of additional variables for inclusion because of their potential impact on the innovation adoption and diffusion (Rogers 2003, Teo et al. 2003, Subramani 2004). Firms in high dynamic industries, such as electronics and high-tech manufacturing, have shorter product lifecycles where time-to-market is of crucial importance (Mendelson and Pillai 1998). These firms show higher revenue volatility and customer turnover while compared to those in low dynamic industries (Tallon and Kraemer 2004). SCM has been indicated as an important weapon for firms to improve their flexibility, customer responsiveness, and time-to-market in the dynamic market (Gunasekaran et al. 2001, Tan et al. 2002, Gunasekaran and Ngai 2004). Some studies thus suggested that industry type is an additional variable for controlling the achievement of SCM process (Narasimhan and Kim 2002, Banker et al. 2006). In addition, firm size has been found to have a positive impact on adoption behavior toward the technology. It is often used in many innovation studies as a proxy measure for total resource, slack resource, and organization structure (Rogers 2003). Moreover, other studies also argued that firm size must be incorporated in the model for controlling some extraneous effects (Narasimhan and Kim 2002, Teo et al. 2003, Subramani 2004, Koufteros et al. 2007). Namely, larger firms are more like to adopt e-SCM than smaller firms because they possess the resources and skills necessary to assimilate the innovation effectively.

3. Research design

A survey study was conducted to collect empirical data. The design of the research is described below.

3.1. Instrument

The instrument used is a three-part questionnaire, as indicated in Appendix. The first part uses a nominal scale, and the other two parts use a 7-point Likert scale.
3.1.1. Basic information

Here, organizational characteristics were collected including industry type, annual revenue, number of employees, and number of suppliers, as well as respondent characteristics including experience, education level, age, and position.

3.1.2. Contextual structure

This part of the questionnaire, as discussed above, concerns two contextual structures: technological and collaborative structures. Technological structure includes three factors: relative advantage, complexity, and ability to provide security. The measured items for relative advantage and complexity were adapted from the instrument developed by Moore and Benbasat (1991), each containing three items. Ability to provide security was defined from Ruppel (2004), including two items. Collaborative structure includes four factors: peer pressure, transaction climate, environmental uncertainty, and supplier interdependence. The measured items for the first two factors were adapted from the instrument developed by Premkumar and Ramamurthy (1995), each containing three items. Environmental uncertainty was adapted from the instrument developed by Patterson et al. (2003), including two items. Supplier interdependence was adapted from the instrument developed by Ranganathan et al. (2004), including two items.

3.1.3. e-SCM diffusion

This part of the questionnaire measures the extent of e-SCM diffusion across trading partners. The nature of IT innovation has been evolving rapidly with a large number of possibly interrelated innovations, which suggests that a wider emphasis on aggregated measures for its performance should be needed. Two dimensions have been chosen for the aggregated measures: the degree of change of behavior across major IS innovations and the degree of change of behavior across major diffusion stages (Fichman 2001). These two dimensions were thus used to identify the diffusion stages of e-SCM, that is, adoption, implementation, and assimilation. Accordingly, the measured items for these two dimensions were defined from the discussions in Ramamurthy et al. (1999) and Ranganathan et al. (2004), each including three items. The first dimension contains three IS innovations: electronic data interchange, information sharing in supply chain, and e-purchase with ordering and fulfillment functions. The second dimension considers three transactional diffusion stages: proportion of total suppliers, proportion of total transactions with suppliers, and average proportion of my suppliers’ transactions with their trading partners. As a result, a total of six items were defined for this part.

3.1.4. Control variables

Firm size was measured using the total number of employees of the firm. It consists of three firm sizes, that is, large size, medium size, and small size. Industry type contains three categories, that is, high-tech manufacturing, traditional manufacturing, and service.

3.2. Sample design

This study mainly discusses the contribution of e-SCM diffusion in organizations. The firms qualifying for this study require massive investment in supply chain technologies and experience in supply chain management. It was therefore assumed that larger firms would be more likely to have this experience. A sample frame of 1500 firms was therefore selected from the 2005 listing of companies in the manufacturing and service sectors published by the Taiwan Stock Exchange Corporation. Moreover, the objective of this study involves understanding managerial issues in e-SCM diffusion. Top managers including vice presidents and manufacturing executives are the persons most familiar with the issues. Previous research has also suggested that senior executives are an appropriate source of information concerning IT investment and benefits (Tallon et al. 2000). Both executives were therefore selected as the respondents, as this avoids the response bias from a single informant.

Most of the sample firms are publicly listed in the stock market and the firms’ information, including basic information, financial reports, and e-mail addresses for top managers, is made publicly available on their web sites. It is therefore convenient to conduct a web-based survey to collect the empirical data. First, an invitation letter asking about their experience in e-SCM diffusion was prepared for the potential respondents. The invitation letter also included a web site hyperlink that instantly directs the potential respondents to an online questionnaire. Furthermore, in order to improve survey return, a follow-up procedure was carried out with another invitation letter for the non-respondents after 2–3 weeks. One month later, the same invitation letter and questionnaire were sent to the non-respondents by regular mail.

3.3. Scale validation

Initially, pretest was conducted for the scale. The scale was carefully examined by selected practitioners and academicians in this area, including translation, wording, structure, and content. Content validity of the scale should be acceptable. After the questionnaire was finalized, 1326 invitation letters were successfully sent out by e-mail to the potential respondents and 202 valid questionnaires were returned. The response rate was 15.3%. The seemingly low response rate raises the concern about non-response bias. To check non-response bias, the responding sample was divided into two parts: early and late groups. The early group was identified as the period of the first two to three weeks after the survey was started, being with 135 respondents. The late group was identified as the period after the follow-up procedure was carried out, being with 67 respondents. The demographic characteristics of the two groups, such as industry type, annual revenue, and number of employees, were compared. The outcome demonstrated no systematic non-response bias. Table 2 summarizes the demographics of the respondents.

3.4. Measurement model

PLS is a structural equation modeling (SEM) technique that employs a nonparametric and component-based approach for estimation purposes. PLS allows minimal demands on sample size and residual distributions (Chin 1998, Chin et al. 2003). Theoretically, the sample size for executing PLS requires 10 times the number of indicators associated with the most complex construct or the largest number of antecedent constructs linking to an endogenous construct. This study has theoretically defined this diffusion as three stages and the total sample needs to be clustered into three sub-samples for the analysis of each of the three stages. PLS is the best analytical tool available to fit the requirement of small sample size. Thus, we used PLS to analyze the research model. A measurement model has been built to assess convergent and discriminant validities of the scale.

First, construct validity is assessed using convergent and discriminant validities. Convergent validity uses three criteria: (1) all item loadings (λ) should be larger than 0.70 and statistically significant, (2) composite construct reliability for each construct should exceed 0.80 and can be interpreted like a Cronbach’s α coefficient, and (3) average variance extracted (AVE) for each construct should be larger than 0.50 (Fornell and Larcker 1981). Next, discriminant validity uses the criterion: construct’s AVE larger than squared correlations with other constructs (Fornell and Larcker 1981, Chin 1998). Table 3 shows the indices for convergent and
Table 2
Demographics.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Frequency</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Industry types</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High-tech manufacturing</td>
<td>128</td>
<td>72.77</td>
</tr>
<tr>
<td>Traditional manufacturing</td>
<td>35</td>
<td>17.33</td>
</tr>
<tr>
<td>Service (software/retailing)</td>
<td>39</td>
<td>9.90</td>
</tr>
<tr>
<td><strong>Annual revenue</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;1000M</td>
<td>91</td>
<td>45.05</td>
</tr>
<tr>
<td>1000–5000M</td>
<td>38</td>
<td>18.81</td>
</tr>
<tr>
<td>5000–10,000M</td>
<td>25</td>
<td>12.38</td>
</tr>
<tr>
<td>10,000–100,000M</td>
<td>23</td>
<td>11.39</td>
</tr>
<tr>
<td>&gt;100B</td>
<td>25</td>
<td>12.38</td>
</tr>
<tr>
<td><strong>Number of employees</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;1000</td>
<td>143</td>
<td>70.79</td>
</tr>
<tr>
<td>1000–2000</td>
<td>10</td>
<td>4.95</td>
</tr>
<tr>
<td>2000–4000</td>
<td>12</td>
<td>5.94</td>
</tr>
<tr>
<td>4000–10,000</td>
<td>9</td>
<td>4.46</td>
</tr>
<tr>
<td>&gt;10,000</td>
<td>28</td>
<td>13.86</td>
</tr>
<tr>
<td><strong>Number of suppliers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;100</td>
<td>132</td>
<td>65.34</td>
</tr>
<tr>
<td>100–300</td>
<td>30</td>
<td>14.85</td>
</tr>
<tr>
<td>300–500</td>
<td>12</td>
<td>5.94</td>
</tr>
<tr>
<td>&gt;500</td>
<td>28</td>
<td>13.86</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>68</td>
<td>33.66</td>
</tr>
<tr>
<td>Male</td>
<td>134</td>
<td>66.34</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;30</td>
<td>32</td>
<td>15.84</td>
</tr>
<tr>
<td>30–40</td>
<td>80</td>
<td>39.60</td>
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<tr>
<td>40–50</td>
<td>61</td>
<td>30.20</td>
</tr>
<tr>
<td>&gt;50</td>
<td>29</td>
<td>14.36</td>
</tr>
<tr>
<td><strong>Working experience</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;10</td>
<td>111</td>
<td>54.95</td>
</tr>
<tr>
<td>10–20</td>
<td>65</td>
<td>32.18</td>
</tr>
<tr>
<td>&gt;20</td>
<td>26</td>
<td>12.87</td>
</tr>
<tr>
<td><strong>Education level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school</td>
<td>15</td>
<td>7.43</td>
</tr>
<tr>
<td>College</td>
<td>131</td>
<td>64.85</td>
</tr>
<tr>
<td>Graduate college</td>
<td>54</td>
<td>26.73</td>
</tr>
<tr>
<td>Ph.D.</td>
<td>2</td>
<td>0.99</td>
</tr>
<tr>
<td><strong>Position</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vice president</td>
<td>40</td>
<td>19.80</td>
</tr>
<tr>
<td>Chief financial officer</td>
<td>10</td>
<td>4.95</td>
</tr>
<tr>
<td>Chief information officer</td>
<td>14</td>
<td>6.93</td>
</tr>
<tr>
<td>Manufacturing executive</td>
<td>74</td>
<td>36.63</td>
</tr>
<tr>
<td>Senior staff or others</td>
<td>64</td>
<td>31.69</td>
</tr>
</tbody>
</table>

discriminant validities. Item loadings range from 0.87 to 0.97 and are significant at the 0.01 level, construct reliabilities range from 0.92 to 0.97, and average variances extracted (AVE) range from 0.79 to 0.94. The results indicate that all constructs have high degrees of reliability and convergent validities. The AVE for each construct is larger than its squared correlations with all other constructs. Thus, all constructs also meet the criterion of discriminant validity.

4. Statistical analysis and hypotheses testing

4.1. Cluster analysis for diffusion stages

An exploratory analysis was conducted to empirically confirm the diffusion stages. Cluster technique was used to group the responding firms based on the six measuring items, as defined previously. First, the hierarchical procedure with Ward’s algorithm was initially used to identify the appropriate number of clusters. The evaluation indices showed three clusters most suitable to this classification. Second, a nonhierarchical procedure with K-means was applied to further adjust the previously obtained result. This analysis finally confirmed the fitness of a three-cluster solution with sample size of 30 (15.0%), 106 (52.5%), and 66 (32.5%), respectively, as shown in Table 4. A rate of 98.0% for the original clustered firms was correctly classified, namely achieving a high degree of classification accuracy. According to cluster centroids, indices for the relative degree of diffusion, the three clusters were positioned in an ascending order of their degree of the diffusion. Based on the previous discussion for diffusion stages, the three clusters could be defined and named as adoption, implementation, and assimilation stages, respectively.

4.2. Hypotheses testing

A structural model with PLS was built to examine the causal structure of the research framework. We performed three separate runs for adoption, implementation, and assimilation with sample sizes of 30, 106, and 66, respectively, and put together their testing results in a table for comparison’s purpose. The evaluation of the structural model was carried out in two steps. First, we needed to estimate standardized path coefficient and statistical significance for the influence paths in the structure model. Bootstrapping analysis was conducted with 100 subsamples to estimate their path coefficients and statistical significance, because PLS does not directly provide confidence interval estimates or significance tests of path coefficients. Second, we needed to compute coefficient of determination (R²) for endogenous variables to assess the predictive power of the structural model. Table 5 presents the results of the hypothesis tests for the contextual variables in our research model.

For the technological structure, we found that relative advantage was reported as an important antecedent of all of the three diffusion stages, adoption (p < 0.01), implementation (p < 0.01), and assimilation (p < 0.05) (Path coefficient, β = 0.55, 0.40, and 0.26). The Relative Advantage Hypothesis (H1) is thus accepted. Complexity had a positive effect on adoption (p < 0.05) and implementation (p < 0.05), but showed no significant effect on assimilation (β = 0.33, 0.33, and 0.15). Thus, the Complexity Hypothesis (H2) is partially accepted. Ability to provide security played a critical role in determining adoption (p < 0.05), but indicated no significant effect on implementation and assimilation (β = 0.23, 0.12, and 0.08). Thus, the Security Provision Hypothesis (H3) is partially accepted.

For the collaborative structure, peer pressure was indicated as an important determinant of all of the three stages, adoption (p < 0.05), implementation (p < 0.05), and assimilation (p < 0.05) (β = 0.28, 0.18, and 0.22). The Peer Pressure Hypothesis (H4) is thus accepted. Transaction climate had a significant impact on assimilation (p < 0.05), but showed no significant impact on the other two stages (β = 0.15, 0.08, and 0.21). Thus, the Transaction Climate Hypothesis (H5) is partially accepted. Environmental uncertainty played an important role in determining implementation, assimilation, but showed no significant role in impacting adoption (β = 0.07, 0.20, and 0.19). Thus, the Environmental Uncertainty Hypothesis (H6) is partially accepted. Supplier interdependence had an influential role in determining assimilation (p < 0.05) while showing no significant effect on the other two stages (β = 0.07, 0.15, and 0.21). Thus, the Supplier Interdependence Hypothesis (H7) is partially accepted. Moreover, the coefficient of determination (R²) for the three dependent variables, adoption, implementation, and assimilation, were 51%, 45%, and 47%, respectively.

In addition, we also found interesting results about the roles of control variables with independent and dependent variables, as shown in Table 6. Among the independent variables, industry type is positively correlated with relative advantage at adoption stage and positively correlated with ability to provide security, transaction climate, and supplier interdependence at implementation.
stage. Furthermore, firm size has significant correlation with ability to provide security at implementation stage and significant correlation with peer pressure and transaction climate at assimilation stage. With respect to the dependent variables, industry type is only positively correlated with assimilation stage. However, firm size does not show any correlation with the three stages.

5. Discussion of the main findings

First, we discuss the effect of technological structure on the three diffusion stages. In general, relative advantage and complexity are both indicated as the significant antecedents at the earlier stages of e-SCM diffusion. Complexity is shown with no significance at assimilation stage. The findings are similar to what others have obtained for the TAM model, when it is applied to other kinds of IT innovations. The reason for this may be explained as below. As e-SCM is new and complex for the users across a large number of trading partners, perceived usefulness (relative advantage) and perceived ease of use (complexity) are therefore shown to be the important drivers for the successful use of the new innovation. Similarly, other researchers also asserted that relative advantage has a positive effect on EDI diffusion (Premkumar et al. 1994, Ramamurthy et al. 1999). However, while IS diffusion progresses in a more advanced level and the users are more familiar with the innovation, perceived ease of use therefore becomes less influential in the impact of system use. In addition, we found that the ability to provide security was only significant in its impacts on the adoption stage. It did not significantly impact the other two stages. e-SCM is mainly built based on an Internet-based and open network for the purpose of sharing information among trading partners. The first priority for trading partners lies in the concern of information security in the beginning stage (Ruppel 2004). When the relationships among participants have evolutionarily become deeper and more stable, the concern of ability to provide security would be in a situation of less attention and the trading partners’ focus would be shifted to other important antecedents, such as transaction climate and supplier interdependence.

Second, we discuss the impact of collaborative structure on the three diffusion stages. Peer pressure is positively correlated with all of the three stages. The reasons for this may be explained as below. Peer pressure has been cited to be an important factor for IT innovation diffusion (Ramamurthy et al. 1999, Ranganathan et al. 2004). If major competitors adopt e-SCM to successfully obtain their goals in the industry, the pressure from competitors may force the firms to adopt the new technology, particularly their

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**Table 3**

Convergent and discriminant validities.

<table>
<thead>
<tr>
<th>Construct</th>
<th>Item loading</th>
<th>Cronbach's α</th>
<th>Composite Reliability</th>
<th>Composite AVE</th>
<th>Squared correlation RA</th>
<th>Squared correlation CP</th>
<th>Squared correlation AS</th>
<th>Squared correlation PP</th>
<th>Squared correlation TC</th>
<th>Squared correlation EU</th>
<th>Squared correlation SI</th>
<th>Squared correlation ED</th>
</tr>
</thead>
<tbody>
<tr>
<td>RA</td>
<td>0.89–0.94</td>
<td>0.90</td>
<td>0.94</td>
<td>0.83</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>CP</td>
<td>0.87–0.91</td>
<td>0.87</td>
<td>0.92</td>
<td>0.79</td>
<td>0.37</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>AS</td>
<td>0.96–0.96</td>
<td>0.92</td>
<td>0.96</td>
<td>0.93</td>
<td>0.30</td>
<td>0.32</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>PP</td>
<td>0.91–0.92</td>
<td>0.90</td>
<td>0.94</td>
<td>0.83</td>
<td>0.27</td>
<td>0.19</td>
<td>0.11</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>TC</td>
<td>0.95–0.96</td>
<td>0.95</td>
<td>0.97</td>
<td>0.91</td>
<td>0.30</td>
<td>0.26</td>
<td>0.34</td>
<td>0.44</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>EU</td>
<td>0.97–0.97</td>
<td>0.93</td>
<td>0.97</td>
<td>0.94</td>
<td>0.27</td>
<td>0.20</td>
<td>0.13</td>
<td>0.53</td>
<td>0.38</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>SI</td>
<td>0.94–0.94</td>
<td>0.87</td>
<td>0.94</td>
<td>0.89</td>
<td>0.36</td>
<td>0.22</td>
<td>0.25</td>
<td>0.52</td>
<td>0.60</td>
<td>0.47</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>ED</td>
<td>0.90–0.93</td>
<td>0.97</td>
<td>0.97</td>
<td>0.85</td>
<td>0.24</td>
<td>0.20</td>
<td>0.08</td>
<td>0.32</td>
<td>0.14</td>
<td>0.26</td>
<td>0.27</td>
<td>–</td>
</tr>
</tbody>
</table>

Relative advantage (RA), complexity (CP), ability to provide security (AS), peer pressure (PP), transaction climate (TC), environmental uncertainty (EU), supplier interdependence (SI), e-SCM diffusion (ED).

**Table 4**

Final cluster centroids of the diffusion stages and discriminant analysis.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Cluster centroids</th>
<th>Number of firms</th>
<th>Discriminant analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D1  D2  D3  D4  D5  D6</td>
<td>Adoption  Implementation  Assimilation</td>
<td></td>
</tr>
<tr>
<td>Adoption</td>
<td>2    2    2    2    2    2</td>
<td>30</td>
<td>30 (100%) 0 (0%) 0 (0%)</td>
</tr>
<tr>
<td>Implementation</td>
<td>4    4    4    4    4    4</td>
<td>106</td>
<td>1 (0.9%) 102 (96.2%) 3 (2.8%)</td>
</tr>
<tr>
<td>Assimilation</td>
<td>6    6    6    6    6    6</td>
<td>66</td>
<td>0 (0%) 0 (0%) 66 (100%)</td>
</tr>
</tbody>
</table>

D1–D6: the six measuring items for e-SCM diffusion.

**Table 5**

Results of the structural model: path coefficients.

<table>
<thead>
<tr>
<th></th>
<th>Adoption (N = 30)</th>
<th>Implementation (N = 106)</th>
<th>Assimilation (N = 66)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technological structure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relative advantage</td>
<td>0.55**</td>
<td>0.40**</td>
<td>0.26*</td>
</tr>
<tr>
<td>Complexity</td>
<td>0.33*</td>
<td>0.33*</td>
<td>0.15</td>
</tr>
<tr>
<td>Ability to provide security</td>
<td>0.23*</td>
<td>0.12</td>
<td>0.08</td>
</tr>
<tr>
<td>Collaborative structure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peer pressure</td>
<td>0.28*</td>
<td>0.18*</td>
<td>0.20*</td>
</tr>
<tr>
<td>Transaction climate</td>
<td>0.15</td>
<td>0.08</td>
<td>0.21*</td>
</tr>
<tr>
<td>Environmental uncertainty</td>
<td>0.07</td>
<td>0.20*</td>
<td>0.19*</td>
</tr>
<tr>
<td>Supplier interdependence</td>
<td>0.07</td>
<td>0.15</td>
<td>0.21*</td>
</tr>
<tr>
<td>R² (%)</td>
<td>51</td>
<td>45</td>
<td>47</td>
</tr>
</tbody>
</table>

* p < 0.05, ** p < 0.01.
supply chain operations, which are closely tied to those of trading partners. Transaction climate only has significant impact in the assimilation stage. This finding is interesting to practitioners. In fact, transaction climate among trading partners is an evolutionary concept which describes the gradual formation of organizations’ values or norms of being willing to participate in trading activities. As e-SCM deployment among suppliers is at the earlier stages, a high level of trust and commitment among them is waiting to be well established.

Environmental uncertainty plays an important role in the latter two stages. The reason is as follows. While some factors such as peer pressure and relative advantage are considered to be critically important for the users in the initial adoption of e-SCM, in contrast, environmental uncertainty may not be their major concern in the initial stage until it has gradually demonstrated the importance of market uncertainty in the future competition. Finally, supplier interdependence demonstrates a similar role as transaction climate in reflecting its effect on assimilation stage. This may be due to the influence of time-lag for a well-established long-term relationship among suppliers. Long-term relationships among suppliers are not ready to be built at the earlier stages until they have worked together for an extended period of time and have committed themselves to a common goal.

Finally, a few words about the control variables are in order. High-tech manufacturing, while compared to traditional manufacturing or service sector, is more likely to demonstrate higher relative advantage at adoption stage. High-tech manufacturing provides more opportunities for building higher levels of ability to provide security, transaction climate, and supplier interdependence at implementation stage. High-tech manufacturing is more capable of facilitating the diffusion in the assimilation stage. Next, larger firm size, while compared to medium or small firm size, is more likely to demonstrate higher level of ability to provide security at implementation stage. Larger firm size is more capable of building higher levels of peer pressure and transaction climate at assimilation stage. Finally, the three dependent variables, adoption, implementation, and assimilation, can be well explained by the attributes of technological and collaborative structures. Overall, the explanatory power of our research model is acceptable.

6. Conclusions

e-SCM has increasingly become an important source of firms’ competitive advantage. This research explores the impact of two important contextual structures, technology and collaboration, on e-SCM diffusion among three stages. Our main results are as follows. In the adoption stage, relative advantage, complexity, ability to provide security, and peer pressure are the important antecedents for e-SCM diffusion. In the implementation stage, relative advantage, complexity, peer pressure, and environmental uncertainty are critical in determining e-SCM diffusion. In the assimilation stage, relative advantage, peer pressure, transaction climate, environmental uncertainty and supplier interdependence have significant roles in influencing e-SCM diffusion. In particular, technological structure is a more important indicator for the adoption stage while collaborative structure is more important for the assimilation stage.

The findings have implications for both practitioners and researchers. Concerning the technological aspect, while e-SCM diffusion is still at the earlier stages (approximately 67.5% of firms at the adoption and implementation stages), the focus for innovation diffusion is on the improvement of perceived usefulness, ease of use, and information security. This implies that the design of e-SCM, which is built with useful functions and a user-friendly interface, is the most important concern for the success of initial adoption. Regarding the collaborative aspect, transaction climate and supplier interdependence are mainly built for an extended period of time to facilitate the success of final assimilation. This will create trust and a close relationship to further build an open network in exchanging information all the time. When the firms face environmental uncertainty in the market, they will adopt e-SCM to improve information exchange and reduce uncertainty between trading partners. Moreover, the future competition within an industry or across industries will not be a single company versus a single company, but a supply chain versus a supply chain. Any firm is undoubtedly an inseparable part of the new industrial structure and needs to adjust itself constantly to fit into this structure. Peer pressure is an important enabler during the whole diffusion process. That is, when key supply chain partners begin adopting e-SCM, other partners within the supply chain will respond to the need to adopt the innovation, especially if their SCM operations are closely tied to those of outside parties. In general, firms should focus on technological concerns for supply chain management during the earlier stages. This will enable them to form the basis for strong collaborative relationships among their trading partners.

Furthermore, future research could be carried out on this foundation. First, this research proposed a theoretical framework for understanding the relationships between two contextual factors and e-SCM diffusion, and further empirically validates it by a large sample survey. Subsequent research should include case studies that will help us to understand the usefulness of this framework in practice. Second, since the sample we selected is from a combination of various industries, the conclusions we drew are more general and comprehensive. Follow-up research could be targeted toward particular industries, for instance, the high-tech electronics industry, to understand their differences and similarities. This
would provide more insight into the practices of this particular industry in using e-SCM. Moreover, while the ultimate goal of e-SCM diffusion is usually indicated by its organizational performance, little research has reported the linkage between innovation diffusion and organizational performance and has considered them as two separate issues (Fichman 2001). Later research could explore the effect of the stage-based process on firm performance.

Finally, although this research has produced some interesting results, a number of limitations may be inherent in it. First, the response rate was lower than desirable, despite the various efforts to improve it. This may be because the respondents lack relevant practical experience in the management of stage-based e-SCM diffusion. However, the responding sample demonstrated no systematic non-response bias. Next, while the questionnaires were originally designed for manufacturing executives, CIOs, or other senior managers in the firms, however, approximately 31.7% of the respondents were non-executive staff. Although this would more or less produce different results in experiencing e-SCM, it could also increase the diversity of data sources from multiple informants since they experience e-SCM diffusion differently, and therefore increase the variance in the variables of interest. In addition, while senior managers of larger firms are always busy, some of the questionnaires might have been completed by subordinates and therefore, the data may have some biases.

Appendix

I. Basic information

(1) Industry type
(2) Annual revenue (NT$ millions)
(3) Number of employees (persons)
(4) Total number of suppliers
(5) Working experience (years)
(6) Education level
(7) Gender
(8) Position
(9) Age

II. Contextual structures

On a scale of 1 (strongly disagree) to 7 (strongly agree), indicate the degree of the following scale items:

1. Technological structure

(1) Using e-SCM enables my firm to accomplish supply chain activities more quickly.
(2) Using e-SCM makes it easier for my firm to do supply chain activities.
(3) Using e-SCM gives my firm greater control over supply chain activities.
(4) My interaction with e-SCM is clear and understandable.
(5) I believe that it is easy to get e-SCM to do what I want it to do.
(6) Learning to operate e-SCM is easy for me.
(7) The communication security of e-SCM affects decision to adopt them.
(8) The communication security of e-SCM impacts how widely I use them.

2. Collaborative structure

(1) My firm experiences pressure for not using e-SCM to meet partner requirements.
(2) My firm experiences pressure from industry for not using e-SCM as a standard purchase practice.
(3) My firm experiences pressure for loss of competitive edge due to lack of e-SCM adoption.
(4) Mutual trust and faith among trading partners makes e-SCM adoption more likely.
(5) A high level of cooperation among trading partners makes e-SCM adoption more likely.
(6) A high level of agreement among trading partners makes e-SCM adoption more likely.
(7) If my firm experiences a high level of market change and uncertainty, it is less likely to adopt e-SCM.
(8) If the industry of which my firm is part experiences a high level of market change and uncertainty, my firm is more likely to adopt e-SCM.
(9) Established mutual relationship with suppliers facilitates e-SCM adoption.
(10) Dependence of suppliers on my firm in achieving their goals facilitates e-SCM adoption.

III. E-SCM diffusion

On a scale of 1 (very low) to 7 (very high), indicate the level of the following scale items:

(1) The extent to which e-SCM is used in facilitating electronic data interchange among trading partners.
(2) The extent to which e-SCM is used in facilitating immediate supply chain information sharing among trading partners.
(3) The extent to which e-SCM is used in facilitating purchase ordering and fulfillment management among trading partners.
(4) The proportion of my firm’s total suppliers interacts with me through e-SCM.
(5) The proportion of my firm’s total transactions with suppliers is done through e-SCM.
(6) The average proportion of my suppliers’ transactions with their partners is done through e-SCM.

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