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The Process of Innovation Assimilation by Firms in Different Countries: A Technology Diffusion Perspective on E-Business

Kevin Zhu, Kenneth L. Kraemer, Sean Xu
The Paul Merage School of Business, University of California, Irvine, California 92697-3125
{kzhu@uci.edu, kkraemer@uci.edu, xinx@uci.edu}

This paper extends our previous studies on the assimilation of Internet-based e-business innovations by firms in an international setting. Drawing upon theories on the process and contexts of technology diffusion, we develop an integrative model to examine three assimilation stages: initiation → adoption → routinization. The model features technological, organizational, and environmental contexts as prominent antecedents of this three-stage assimilation process. Based on this model, we hypothesize how technology readiness, technology integration, firm size, global scope, managerial obstacles, competition intensity, and regulatory environment influence e-business assimilation at the firm level. A unique data set of 1,857 firms from 10 countries is used to test the conceptual model and hypotheses. To probe deeper into the influence of the environmental context, we compare two subsamples from developed and developing countries. Our empirical analysis leads to several key findings: (1) *Competition* positively affects initiation and adoption, but negatively impacts routinization, suggesting that too much competition is not necessarily good for technology assimilation because it drives firms to chase the latest technologies without learning how to use existing ones effectively. (2) Large firms tend to enjoy resource advantages at the initiation stage, but have to overcome structural inertia in later stages. (3) We also find that economic environments shape innovation assimilation: Regulatory environment plays a more important role in developing countries than in developed countries. Moreover, while technology *readiness* is the strongest factor facilitating assimilation in developing countries, technology *integration* turns out to be the strongest in developed countries, implying that as e-business evolves, the key determinant of its assimilation shifts from accumulation to *integration* of technologies. Together, these findings offer insights into how innovation assimilation is influenced by contextual factors, and how the effects may vary across different stages and in different environments.

Key words: technology diffusion; innovation assimilation; assimilation process; e-business; competition; firm size; technology integration; international perspective
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1. Introduction

With the rapid development of network technologies and open standards and the associated reduction of communication costs, firms are migrating toward the Internet-based digital platform that holds the promise of substantial productivity gains. It has been widely noted that technological innovations such as the Internet are a primary driver of industrial productivity (Greenspan 2002), but if promising innovations cannot be widely adopted, the benefits resulting from their invention will be curtailed (Zhu et al. 2006a). To fully realize the business value of the Internet, the diffusion of electronic business by firms stands out as an important research topic (Geoffrion and Krishnan 2003). This study focuses on Internet-based *electronic business* (e-business), which refers to conducting value chain activities (including sales, customer services, procurement, information sharing and coordination with suppliers) by using the Internet platform (e.g., TCP/IP, HTTP, XML) in conjunction with existing information technology (IT) infrastructure (Zhu and Kraemer 2005). As exemplars of success, traditional firms such as Dell, Cisco, General Electric, Wal-Mart, and Charles Schwab, along with firms "born on the Internet," like Amazon and eBay, have shown the potential of e-business to enhance customer services, streamline internal operations, and improve interfirm coordination (Straub et al. 2002). Empirical research on e-business also shows its positive impacts on firm performance (Zhu and Kraemer 2002, Barua et al. 2004).

On the other hand, the processes of diffusion rarely unfold in a smooth and linear fashion (NIST 2004). Many firms failed to achieve deep usage beyond initial adoption (Chatterjee et al. 2002). Prior studies on innovation diffusion show that an innovation must be integrated or ingrained into the corporate value chain before it can generate significant business value (DeLone and McLean 1992, Sethi and King 1994, Devaraj and Kohli 2003). Developing e-business capability is an important undertaking because it encompasses enabling sell-side, buy-side, and internal business processes (Zhu 2004). E-business assimilation becomes a significant research topic because it is about enhancing operational efficiency and competitive agility for long-term survival of the firm (Zhu and Kraemer 2002, 2005).

Drawing upon the innovation diffusion literature (see Fichman 2000 for a review), we define *e-business assimilation* as a series of stages from a firm's initial evaluation of e-business at the preadoption stage (initiation), to its formal adoption, and finally to its full-scale deployment at the postadoption stage in which e-business becomes an integral part of the value chain activities (routinization). Initial efforts in academia have been devoted to studying e-business adoption (e.g., Zhu et al. 2003), and they have significantly expanded our knowledge frontier. However, much existing research is focused on a single stage, such as one-shot adoption decisions, and we know little about the various stages of e-business assimilation. Literature review by Fichman (2000) and Zhu et al. (2006b) suggests that the postadoption stages of assimilation are especially worthy of a focused study.

Further, it is important to understand the key factors that influence e-business assimilation. Internet technologies enable a variety of functionalities to support value chain processes (Porter 2001). Thus, e-business assimilation requires coevolutionary changes to systems-in-use and the new Internet technologies (Devaraj and Kohli 2003). Beyond technologies, Chatterjee et al. (2002) identified significant organizational enablers, including management support and cross-department coordination. Moreover, influences from the environment could also affect e-business assimilation. For instance, Zhu et al. (2006a) found that a firm's adoption of network technologies was significantly influenced by peer adoption in the same industry. Yet, these factors (technological, organizational, environmental) were examined separately in different models and based on different data sets. The literature lacks a unified theoretical framework to guide empirical research. This motivates us to develop an integrated model so that we can begin to investigate the assimilation stages and contextual factors.

Moreover, this model should allow us to examine how these factors may have differential effects at different assimilation stages. That is, the same factors may have "differently directioned effects," depending on the stages of assimilation (Fichman 2000). However, studies of IT innovation have not found much support for this hypothesis (Fichman and Kemerer 1999, Grover and Goslar 1993, Zmud 1982), and a meta-analysis has found that these variables have effects in the same direction throughout the assimilation process (Damanpour 1991). As it turns out, this important proposition has not been fully tested, which leaves a gap in our understanding of differences across assimilation stages (Fichman 2000).

Finally, as pointed out by Zhu and Kraemer (2005, p. 62) "prior research argued that theories developed in the context of mature markets and industrialized economies need to be reexamined in the context of developing countries, because these countries may have very different economic and regulatory environments… . Rosenzweig (1994) challenges the presumption of conceptual equivalence across cultural and economic barriers in management science research." Despite the fact that the Internet supports worldwide connectivity and e-business is a global phenomenon (Zhu et al. 2006b), most existing studies in this area have been focused on one country, predominantly the United States (Zhu et al. 2004). Seeking to bridge this gap, we propose to examine to what extent innovation theories can be generalized in different economic contexts. Along this line, we study e-business assimilation in an international setting, extending beyond the United States to encompass the firm-level evidence in other countries, which might represent different stages of e-business transformation (UNCTAD 2002).

Motivated by the issues identified above, we seek to study the following research questions: (1) In searching for an integrated framework, what theoretical perspectives can be used to study e-business assimilation? (2) What specific factors would affect e-business assimilation, and how do their effects vary at different stages? (3) Furthermore, examining an international dimension, how would these effects vary across different economic environments in developed versus developing countries. To better understand these questions, we first developed a model grounded in theoretical perspectives on the stages and contexts of technology diffusion. The model specified seven contextual factors and three assimilation stages. We then tested the model using a unique data set of 1,857 firms in three major industries from 10 economies (both developed and developing countries). Based on structural equation modeling, our data analysis identifies significant factors shaping e-business assimilation and reveals differential effects across the three assimilation stages and between developed and developing counties.

2. The Theory of Innovation Assimilation

2.1. The Stages of Innovation Assimilation

According to the innovation diffusion literature (Rogers 1995, Meyer and Goes 1988), the assimilation of an innovation starts from a firm's initial awareness and evaluation of the innovation. This initial stage "amounts both to identifying and prioritizing needs and problems on one hand, and to searching the organization's environment to locate innovations of potential usefulness to meet the organization's problems" (Rogers 1995, p. 391). The degree to which an innovation fits the problem to be solved will influence the decision to adopt the innovation. The IT literature (Armstrong and Sambamurthy 1999, Sethi and King 1994) suggests that the potential of IT to enhance a firm's performance in value chain activities (Porter 1985) is a significant motivation for the firm to adopt IT. Applying this view to e-business, we define *e-business initiation*—the first stage of e-business assimilation—as evaluating the potential benefits of e-business to improve a firm's performance in value chain activities such as cost reduction, market expansion, and supply chain coordination.

Following initiation is the stage of adoption. Consistent with the technology adoption literature (Rogers 1995, Chau and Tam 1997), we define *e-business adoption*—the second stage of e-business assimilation—as making the decision to use the Internet for value chain activities (i.e., allocating resources and physically acquiring the technology). A number of studies examined antecedents of IT adoption decisions and found significant differences between adopters and nonadopters in terms of internal resources and external environments (Iacovou et al. 1995, Chau and Tam 1997, Zhu et al. 2003). Because the adoption decision legitimizes resource allocation required by the general deployment of the innovation (Cooper and Zmud 1990), this stage is deemed a necessary step toward the widespread usage of the technology.

Yet, adoption does not always result in widespread usage of the technology by a firm. Assimilation theories suggest that most information technologies exhibit an "assimilation gap," i.e., their widespread usage tends to lag behind their adoption (Fichman and Kemerer 1999). "A new technology may be introduced amid great enthusiasm and enjoy widespread initial acquisition, but nevertheless still fails to be thoroughly deployed among many acquiring firms" (Fichman and Kemerer 1999). After a new IT innovation is adopted, it needs to be accepted, adapted, routinized, and institutionalized into the firm. After its initial adoption, the firm and its members usually do not have sufficient knowledge to leverage the system, and often misalignments occur between the new technology and the user environment (Fichman and Kemerer 1999). In a study of material requirements planning (MRP) systems, Cooper and Zmud (1990) reported that, while 73% of the surveyed firms had adopted MRP, only 27% of them had integrated MRP into their capacity planning, which indicated a significant assimilation gap. In another study of software practices, Fichman and Kemerer (1999) found that although 42% of surveyed firms had adopted computer-aided software engineering (CASE), only 7% of the firms had achieved "widespread deployment"—defined as the use of CASE in at least 25% of software development projects (Fichman and Kemerer 1999). This stream of research has an important implication for our present study: Adoption and routinization are two distinct stages. *E-business routinization*—the third stage of e-business assimilation—is defined as the stage in which e-business is widely used as an integral part in a firm's value chain activities. Moreover, in the information systems (IS) literature, routinization has been proposed as a significant dimension of IS success (DeLone and McLean 1992). Thus, routinization in its own right is an important construct worthy of research.

Based on the above theoretical considerations and literature review, we specify *initiation, adoption*, and *routinization* as three stages of e-business *assimilation*. This is consistent with the classic conceptual work of Thompson (1965) that analyzed innovation assimilation by considering a sequence from initiation to adoption and then to implementation, which had empirical support from subsequent literature (Zmud 1982, Grover and Goslar 1993). Thompson (1965) defined implementation as the extent to which development, feedback, and adjustment activities are performed to ensure the innovation becomes ingrained within business activities. This is consistent with our definition of routinization and offers further theoretical support for our three-stage model. Next, we look to identify factors influencing the three assimilation stages. Toward this end, we draw upon a theoretical framework about assimilation contexts, which is discussed next.

2.2. The Contexts of Innovation Assimilation

A theoretical model for e-business assimilation needs to consider factors that influence the propensity to adopt and use the innovation, which is rooted in the specific technological, organizational, and environmental contexts of an organization. Reviewing the literature suggests that the *technology-orgaization-environment* (TOE) framework (Tornatzky and Fleischer 1990) is appropriate to study contextual factors that influence e-business assimilation. The TOE framework identifies three aspects of a firm's context that influence its assimilation of a technological innovation: (a) *Technological context* describes both the existing technologies in use and new technologies relevant to the firm. (b) *Organizational context* refers to descriptive measures about the organization such as scope, size, and managerial structure. (c) *Environmental context* is the arena in which a firm conducts its business—its industry, competitors, and dealings with government (Tornatzky and Fleischer 1990, pp. 152–154). This framework is consistent with the innovation diffusion theory of Rogers (1995, pp. 376–383) in which he emphasized technological characteristics, and both the internal and external characteristics of the organization, as drivers for technology diffusion.

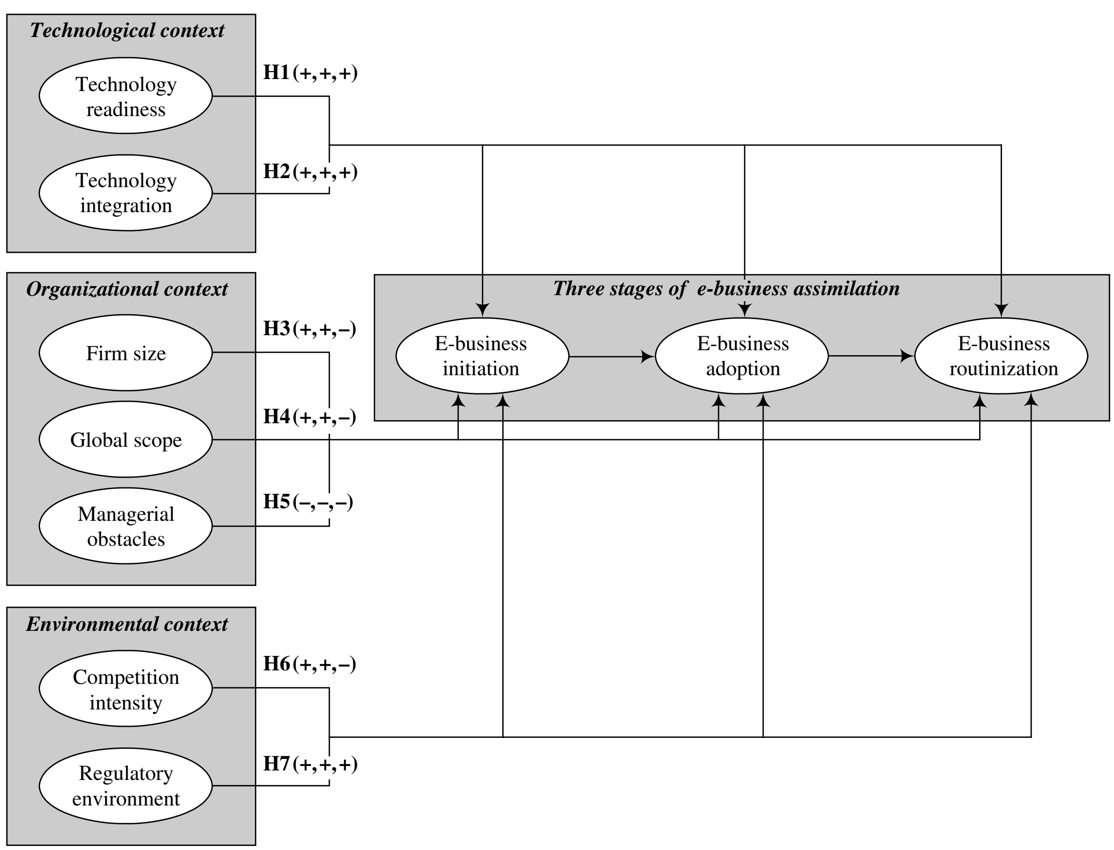
The TOE framework, as described above, has been used in our earlier studies. Zhu et al. (2003) drew upon the TOE framework to identify facilitators and inhibitors for e-business *adoption* decisions by European firms. Zhu and Kraemer (2005) examined the role of the TOE factors to influence e-business *usage* in the retail industry. Focused on the financial services sector, Zhu et al. (2004) studied how TOE factors may influence e-business *impacts* on firm performance. More broadly, the TOE framework has been examined by a number of empirical studies on technology adoption, especially on the adoption of electronic data interchange (EDI). Consistent with Tornatzky and Fleischer (1990), Iacovou et al. (1995) developed a model formulating *technological, organizational*, and *environmental* factors as the main drivers for EDI adoption, and examined the model using seven case studies. Chau and Tam (1997) applied the TOE framework to study open systems adoption, using data from 89 organizations. Their analyses demonstrated the value of using the TOE framework to understand the adoption of a complex IS innovation. Furthermore, they suggested that, "one future line of research is to extend the proposed [TOE] framework to other innovation domains" (Chau and Tam 1997). Research on other information systems (see Zhu et al. 2003 for a literature review) also provided empirical support for this theoretical framework. After reviewing its theoretical roots and empirical evidence, we find that the TOE framework has consistent empirical support, although specific measures identified within the three contexts may vary across different studies. Integrating this framework with the three-stage conceptualization, we develop a conceptual model for e-business assimilation, which is discussed next.

3. Theoretical Development

3.1. The Conceptual Model

Grounded in assimilation stages and assimilation contexts discussed above, we develop a conceptual model as shown in Figure 1. Drawing upon our earlier dis-

Figure 1 The Conceptual Model



cussion, we posit e-business initiation, adoption, and routinization as dependent variables (shown in the middle-right box in Figure 1). The model also incorporates the technological, organizational, and environmental contexts (represented by the three boxes on the left side of Figure 1) as explanatory variables. Some of these variables are drawn from our previous work, as described in Figure 1.

To propose specific factors within the three TOE contexts, we first consider those factors that have been found to be significant for innovation diffusion by existing literature. First, as reviewed in Zhu and Kraemer (2005) technology readiness (infrastructure, relevant systems, technical skills) is an important factor for successful IS adoption, which was conceptually proposed in Kwon and Zmud (1987) and also supported by a number of empirical studies (Iacovou et al. 1995; Armstrong and Sambamurthy 1999; Zhu et al. 2003, 2004). Thus, we incorporate technology readiness within the technological context. Second, as documented in the innovation literature (Damanpour 1996), firm size and firm scope are two major organizational features that influence innovation diffusion. The IS literature has also provided evidence for the significant relationships of firm size and firm scope to IT adoption and usage (Gurbaxani and Whang 1991, Zhu et al. 2003). Hence, we posit firm size and global scope (a proxy of firm scope in the global market—to be elaborated later) within the organizational context. Third, the literature has consistently suggested the significant effect of competition on innovation diffusion (Rogers 1995, Kamien and Schwartz 1982). Because competition drives firms to adopt a new innovation (Kamien and Schwartz 1982), we include competition intensity in the environmental context.

Further, we consider what other factors should be incorporated in the model to reflect the unique features of e-business. First, the e-business literature suggests the critical role of an integrated technological platform in e-business implementation (Zhu and Kraemer 2005). Technology integration is an important dimension for studying the technological context of e-business because it is enabled by the open-standard nature of the Internet (Zhu and Kraemer 2002, 2005). Several online retailers failed to fulfill customer orders during the holiday seasons due to the lack of integration among backend technologies (Lee and Whang 2001). Many such real-world examples illustrate the critical importance of technology integration for e-business (Pastore 2001). Therefore, we incorporate technology integration within the technological context, which represents a higher level of technology usage than technology readiness. Second, e-business requires organizational adaptation (Straub and Watson 2001), such as business processes reengineering (Devaraj and Kohli 2003) and organizational restructuring (Chatterjee et al. 2002), which in turn demands firms to possess relevant managerial skills. Accordingly, the lack of such skills—i.e., managerial obstacles—would be a significant barrier to e-business assimilation. Therefore, we include managerial obstacles within the organizational context. Third, because the environment presents both constraints and opportunities for technological innovation, e-business is influenced by environmental factors related to competition (Porter 2001) and regulation (Zhu et al. 2004). In particular, regulatory environment is a unique feature of e-business (Kraemer et al. 2006). The open-standard nature of the Internet brings unique issues regarding business law, security, credit card use, and online transactions with parties that have no prior relationship, which in turn poses unique demands on regulatory support (different from EDI). In addition, a government's willingness to embrace e-business brings direct (required for government procurement) and indirect (no taxation of Internet sales) stimulus for its use (Kraemer et al. 2006). Thus, a regulatory environment is another critical factor that should be examined within the environmental context.

In summary, after reviewing the innovation diffusion literature and considering the unique features of e-business, we propose a conceptual model (as shown in Figure 1) in which the three-stage assimilation is a function of technological, organizational, and environmental contexts, which are further captured by technology readiness, technology integration, firm size, global scope, managerial obstacles, competition intensity, and regulatory environment. These seven factors are shown in the three boxes on the left-hand side of Figure 1.[1] As we develop formal hypotheses below, we provide further justification why we include them in the model.

3.2. Hypotheses

Technological Context. Two factors are specified within the technological context—technology readiness and technology integration. *Technology readiness* "consists of technology infrastructure and IT human resources, and technology infrastructure refers

[1] This work falls into our cumulative body of research on TOE factors and e-business diffusion (see Zhu et al. 2006b for a literature review). Some of the TOE factors proposed in the conceptual model (Figure 1) have been examined by previous work with different foci. For instance, Zhu and Kraemer (2005) and Zhu et al. (2004) studied the role of firm size, global scope, competition intensity, and regulatory environment at single stages—use and value creation respectively. In this work, these factors are adopted while new factors are proposed such as managerial obstacles, and new insights are expected such as the relative importance between technology readiness and technology integration. More importantly, the current paper focuses on the *process* of assimilation, which is a unique feature compared to the previous research.

to technologies that enable Internet-related businesses… and IT human resources refer to IT professionals possessing the knowledge and skills to implement Internet-related applications" (Zhu and Kraemer 2005, p. 68). By this definition, technology readiness "is reflected not only by physical assets, but also by human resources that are complementary to physical assets (Mata et al. 1995)…. Technology infrastructure establishes a platform on which e-business can be built; IT human resources provide the knowledge and skills to develop e-business applications" (Zhu and Kraemer 2005, p. 69). Therefore, firms with greater technology readiness are in a better position to initiate, adopt, and routinize e-business. Yet, the effect of technology readiness may vary in strength across assimilation stages, in the sense that technology readiness is a fairly positive factor for initiation, but it becomes much more important for the actual adoption and usage of e-business. E-business is unlikely to become an integral part of the value chain if firms lack necessary infrastructure and technical skills (Zhu et al. 2003). Therefore, we expect a stronger effect of technology readiness on the latter stages than on the initiation stage. These considerations lead to the following hypothesis:

Hypothesis 1. *Technology readiness is positively related to e-business initiation, adoption, and routinization, but its effect is greater on adoption and routinization than on initiation.*

Technology integration is defined as the degree of inter-connectivity among back-office information systems and databases inside the firm and those externally integrated with suppliers' enterprise systems and databases (Zhu and Kraemer 2005). The aim of technology integration is to reduce incompatibility between legacy systems and to enhance responsiveness of information systems (Goodhue et al. 1992). Technology integration represents firms' ability to effectively convert common technologies into capabilities (Mata et al. 1995). Evidence from the literature suggests that integrated technologies help improve firm performance by reduced cycle time, improved customer service, and lowered procurement costs (Barua et al. 2004). Technology integration is critical for e-business because e-business requires streamlined data flows along the value chain, and e-business systems should automatically communicate order changes in downstream processes or systems (e.g., manufacturing and inventory systems of the firm and its suppliers; Zhu and Kraemer 2002). Lee et al. (2004, p. 131) showed that "a no-name manufacturer had used IT strategically to gain competitive advantage by developing a sophisticated information system to manage the supply chain of its major retailer customers while at the same time providing backward integration into its own production and material sourcing networks." The key was process integration and synchronization through IT (Lee et al. 2004). Moreover, many e-business initiatives such as the one-click buy and the single-customer view (i.e., integrated services via one customer interface) call for a tight connection among IS modules and applications (Zhu and Kraemer 2005). Thus, firms with higher degrees of technology integration tend to enjoy advantages in initiating and adopting e-business innovations and are more likely to achieve routinization. Thus, technology integration is important for all three stages.

Hypothesis 2. *Technology integration is positively related to e-business initiation, adoption, and routinization.*

Organizational Context. The organizational context includes three factors—firm size, global scope, and managerial obstacles. *Firm size* is an important organizational attribute for innovation diffusion (Rogers 1995). In a meta-analytic review of firm size and innovation, Damanpour (1996) argued that the association between firm size and assimilation stages may differ because of differences in the nature of activities pertaining to each stage. In line with this conceptual analysis of general innovations, we propose differential effects of firm size on different stages of e-business assimilation.

On one hand, large-size firms are expected to facilitate innovation initiation and adoption because they tend to enjoy resource advantages (Rogers 1995, Damanpour 1996). "[Firm] size is probably a surrogate measure of several dimensions that lead to innovation: total resources, slack resources, technical expertise of employees" (Rogers 1995, p. 379). Because conducting e-business requires commitment of financial, technical, and managerial resources, larger firms are more likely to initiate and adopt e-business, given their resource advantages. Prior empirical studies seemed to support this relationship. Based on data of 3,103 firms, Zhu et al. (2003) found that larger firms were more likely to make dedicated investments in e-business.

On the other hand, large firms may embed structural inertia, a negative factor for innovation routinization (Nord and Tucker 1987). E-business routinization requires adopting firms to adapt existing IS (Barua et al. 2004), redesign business processes (Zhu et al. 2004), and adjust organizational structure (Chatterjee et al. 2002). In general, large firms may have more fragmented legacy information systems, which tend to increase the complexity and costs of systems adaptation (Goodhue et al. 1992). Moreover, changes in structures and processes in large firms may be "further complicated by complex business processes, entrenched organizational structure, and hierarchical decision making" (Zhu et al. 2004, p. 42). These factors would translate into structural inertia that may retard routinization. This discussion leads to the following hypothesis:

Hypothesis 3. *Firm size is positively related to e-business initiation and adoption, but negatively related to routinization.*

Global scope is posited as another organizational factor because the Internet is an open platform with global connectivity. Following Zhu et al. (2004, p. 28) *scope* is defined as "the geographical extent of a firm's operations in the global market" (hence, global scope). As discussed in Zhu and Kraemer (2005, p. 69), "this definition is narrower than the literature, yet it is consistent with the international perspective of our research design and our geographical, multicountry emphasis on globalization of e-business, as opposed to the product orientation typically used in the literature (Teece 1980)." The effect of global scope can be explained from a transaction-cost perspective (Williamson 1983), which has been proposed by Zhu et al. (2004). Companies may face a steep rise in transaction costs when they expand into heterogeneous markets (Gurbaxani and Whang 1991). For instance, firms operating in different geographic regions need to locate the target market and form channels in every region (Teece 1980), resulting in higher search costs (search of consumers, trading partners, distributors). Firms conducting business in multiple market segments have to control demand uncertainty in all segments simultaneously, which causes higher inventory holding costs (Zhu et al. 2004). As shown in the literature, e-business may reduce transaction costs (Garicano and Kaplan 2001), lower search costs for customers and suppliers (Malone et al. 1987), and reduce market friction through increased information transparency facilitated by open-standard communication (Zhu 2004). Thus, firms with greater global scope have greater incentives to initiate and adopt e-business. Yet, greater scope could slow down the routinization stage, given the associated process reengineering and organizational restructuring required by the routinization of e-business. This leads to the following hypothesis:

Hypothesis 4. *Global scope is positively related to e-business initiation and adoption, but negatively related to routinization.*

E-business requires firms to transform traditional systems heavily dependent on physical processes to those that rely on digital assets and information flow (Zhu and Kraemer 2005). Associated with this digital transformation, e-business assimilation brings about unique challenges with regard to organizational adaptations (Chatterjee et al. 2002). Not all firms can effectively manage organizational adaptations, partly due to lack of managerial skills and know-how for change management (Roberts et al. 2003). To address this barrier to e-business assimilation, we propose to test the effect of *managerial obstacles*, which refer to the lack of managerial skills for managing organizational adaptations to accommodate e-business. The rationale underlying this construct draws upon the insight from Mata et al. (1995) that the ability to blend managerial and IT skills lies at the heart of firms' ability to assimilate information technology.

According to the literature, organizational adaptations in e-business assimilation include making organizational changes on structures and coordination mechanisms (Chatterjee et al. 2002, Orlikowski and Hofman 1997), mutually adapting e-business and existing strategy and processes to achieve alignment and integration (Straub and Watson 2001), and acquiring new expertise necessary to use the innovation (Fichman and Kemerer 1999). The IT practice literature is replete with stories of IT failures that occur more from these management issues, such as lack of synergy between business and IT skills, knowledge of how to integrate the technology with the business strategy, skilled technical people, and experienced, trained users. This discussion leads us to posit that, when firms confront obstacles in making organizational changes, redesigning processes, and acquiring new expertise, it is difficult to achieve a smooth digital transformation and deep assimilation of e-business. Yet this has not been empirically tested. Hence, we hypothesize and propose to test whether managerial obstacles as defined above are a significant barrier to e-business assimilation:

Hypothesis 5. *Managerial obstacles are negatively related to e-business initiation, adoption, and routinization.*

Environmental Context. Two factors in the environmental context are expected to affect e-business assimilation: competition intensity and regulatory environment. *Competition intensity* is defined as "the degree that the company is affected by competitors in the market" (Zhu et al. 2004, p. 24). Its effect on e-business assimilation may vary as assimilation progresses to a deeper stage. Competition may first drive firms to initiate and adopt innovations to maintain a competitive edge. In a conceptual study of the strategic rationale underlying IT innovations, Porter and Millar (1985) contended that, by adopting information systems, firms might alter the rules of competition, affect the industry structure, and leverage new ways to outperform rivals. Based on Internet technologies, e-business applications can help firms improve market responsiveness and information transparency

(Zhu 2004), increase operational efficiencies (Zhu and Kraemer 2002), and achieve customer lock-in (Shapiro and Varian 1999). These initiatives are critical for firms to maintain their competitive edge (Zhu and Kraemer 2005). Thus, competition is likely to drive firms to initiate and adopt e-business. However, competition might have a different effect on routinization. To explain why most information technologies exhibit an "assimilation gap," Fichman and Kemerer (1999) argued that, to routinize complex technologies, firms need deep technical and managerial skills beyond simple awareness of the innovation. The necessary skills can be acquired mainly through a learning-by-using process (Fichman and Kemerer 1999). However, firms in a more competitive environment would be driven by competitive pressure to leap rapidly from one technology to the next (Abrahamson 1991). As a result, firms are less likely to undergo a gradual, careful, and sustained learning-by-doing process to develop skills for routinizing existing technologies (Mata et al. 1995). E-business is particularly prone to this pattern (Pastore 2001), which may retard its routinization.

Hypothesis 6. *Competition intensity is positively related to e-business initiation and adoption, but negatively related to routinization.*

Within the environmental context, the *regulatory environment* has been recognized as a critical factor influencing innovation diffusion (Zhu et al. 2003, 2004). "This concept is similar to government policy theorized to affect IT diffusion in Umanath and Campbell (1994) and empirically tested in Dasgupta et al. (1999). The latter found that companies operating in an environment in which government policies are restrictive have low IT adoption" (Zhu and Kraemer 2005, p. 70). This is also consistent with Williamson (1983, p. 126), who summarized two ways in which government regulation could affect innovation diffusion: "One is to take specific action to increase or decrease payoffs—by taking tax and other measures.... The second way of influencing innovations is by altering the climate in which they are received." The latter is consistent with the empirical findings and is particularly applicable to e-business. Companies frequently cite inadequate legal protection for online business activities, unclear business laws, and security and privacy concerns as common concerns to doing e-business (Kraemer et al. 2006). Accordingly, governments can encourage e-business assimilation by supportive regulations and policies in three areas: developing supportive e-business legislation on key issues such as digital signatures, electronic transactions, and intellectual property; regulating the Internet to make it a trustworthy business platform by establishing privacy and consumer protection laws and dealing with fraud and credit card misuse; and providing incentives for using e-business in government procurements and contracts such as offering technical support, training, and funding for e-business use (Kraemer et al. 2006).

Hypothesis 7. *A supportive regulatory environment is positively related to e-business initiation, adoption, and routinization.*

Cross-Country Effects. Extending the environmental context of the TOE framework, we want to understand whether the relationships hypothesized above may differ across countries as motivated by the international perspective of our study.[2] Diffusion research on general information technologies has found that IT diffusion occurs unevenly across countries with different environments (Kraemer et al. 2006, Caselli and Coleman 2001). Regarding e-business diffusion, the Asia-Pacific region, Latin America, and Eastern Europe have been experiencing rapid e-business adoption, but a very low volume of transactions (only 4.6% of worldwide e-business volume in 2002), while North America and Western Europe account for 95.4% of worldwide e-business transactions (UNCTAD 2002). Particularly, e-business has evolved into deeper stages of information sharing, supply chain coordination, and business-process optimization in developed countries (Zhu and Kraemer 2005).

In addition to the different levels of e-business diffusion, developed and developing countries differ in terms of factors shaping that diffusion (Zhu and Kraemer 2005). The existing IT literature has highlighted significant barriers to e-business assimilation in developing countries. For instance, within the technological context, firms in developing countries have less-developed IT infrastructure (Dasgupta et al. 1999). Thus, building technology infrastructure would be a more important task for these firms, leading to a more significant effect of technology readiness on e-business assimilation. Within the organizational context, managerial obstacles may be more significant for firms in developing countries because they have less experience of using e-business (Kraemer et al. 2006). Thus, they likely lack managerial skills that are learning-by-using in nature (Mata et al. 1995). Within the environmental context, e-business legislation (e.g., digital signatures, privacy, consumer protection) is less comprehensive in developing countries (Kraemer et al. 2006). Hence, establishing a supportive regulatory framework is deemed to be more critical in these countries. Based on these considerations, we expect a significant moderation effect of

[2] With regard to the cross-country effects, Zhu et al. (2004) conducted a post hoc analysis without developing a hypothesis, while Zhu and Kraemer (2005) first theorized cross-country differences as a formal hypothesis.

Table 1 Sample Characteristics ($N = 1,857$)

Category	Percentage	Category	Percentage
Country		Industry	
Brazil	8.5	Manufacturing	35.6
China	9.7	Retail/wholesale distribution	31.4
Denmark	9.0	Financial services	33.0
France	9.6	Number of employees in the firm	
Germany	9.6	<100	15.4
Japan	11.1	100–300	17.0
Mexico	9.2	300–500	13.3
Singapore	9.6	500–1,000	15.3
Taiwan Province (China)	8.9	1,000–5,000	22.3
United States	14.8	>5,000	16.7
Annual revenue ($ million)		Respondent title	
<1	5.4	*IS Managers*	
1–10	21.8	CIO, CTO, VP of IS or E-Business	16.9
10–50	25.7	IS Manager, Director, Planner	34.9
50–100	10.7	Other Managers in IS Department	21.6
100–500	19.5	*Non-IS Managers*	
500–1,000	6.4	CEO, President, Director	3.3
>1,000	10.5	Business Operations Manager, COO	4.6
		Administration/Finance Manager, CFO	8.2
		Others (Marketing VP, Other Managers)	10.4

the economic environments, and put forth our final hypothesis:

Hypothesis 8. *The relationships between e-business assimilation and TOE factors* (*e.g., technology readiness, managerial obstacles, and regulatory environment*) *are more significant in developing countries than in developed countries.*

4. The Empirical Study

4.1. Data

To test the conceptual model and the associated hypotheses proposed above, a large-scale survey of firms in three major industries (manufacturing, retail/wholesale, financial services) was conducted across 10 countries.[3] Each of the questionnaire items was reviewed by an expert panel for its content, scope, and purpose (content validity). After the questionnaire was finalized, the survey was executed via computer-aided telephone interviews by the Center for Research on Information Technology and Organizations (CRITO) in partnership with International Data Corporation (IDC) and Market Probe, two professional research firms that specialize in large-scale surveys within IT user communities in many countries.

To get a broad representation of both developed and developing countries, the survey was conducted in 10 economies (Brazil, China, Denmark, France, Germany, Japan, Mexico, Singapore, Taiwan, United States) during February–April 2002. The sampling was a stratified sample by country, industry, and firm size, with sites selected randomly within each category to minimize bias. The sample frame was obtained from a list source representative of the entire local market. At the beginning of the survey, a screening question was asked to ensure the respondent was the most-informed person in the firm to answer the questionnaire. The final data set contains 1,857 respondents. We checked for consistency of the data and any potential biases on key variables. We found that distribution of firm size reflected a balance of large and small businesses, and there was no apparent bias across the countries. Then, we examined the so-called "common method bias" (Podsakoff et al. 2003), and the result suggested no significant common method bias in our data set. We also examined nonresponse bias, and no statistically significant differences were found. Table 1 shows the sample characteristics.

Because respondents in our survey include both IS and non-IS managers, one may suspect that IS and non-IS managers tend to have different perceptions about IS usage and benefits (Zhu and Kraemer 2005). For this reason, it is worthwhile to conduct a formal test to examine whether responses provided by IS managers differ significantly from those provided by non-IS managers. To do so, we split the sample into two groups: IS managers (CIO, CTO, VP of IS, and IS manager/director) and non-IS managers (CEO, president, COO, CFO, and other business managers). We used the Kolmogorov-Smirnov (K-S) test to compare

[3] Portions of the database had been used in our previous research: Zhu et al. (2004) used data of the financial services industry and Zhu and Kraemer (2005) used data of the retail/wholesale industry. As more data became available, the present research used data from all three industries to study e-business assimilation. The database and the overall project are described in detail in Kraemer et al. (2006).

Table 2 Descriptive Statistics

	Full sample ($N = 1{,}857$)		IS managers ($N = 1{,}364$)		Non-IS managers ($N = 493$)		Kolmogorov-Smirnov test	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Z-score	p-value
E-business initiation	1.89	0.64	1.90	0.64	1.89	0.64	0.45	0.99
E-business adoption	3.25	1.94	3.20	1.91	3.37	2.01	0.89	0.41
E-business routinization	3.46	5.12	3.60	5.13	3.01	5.10	0.61	0.85
Technology readiness	2.41	0.63	2.43	0.62	2.37	0.69	1.15	0.14
Technology integration	1.74	0.84	1.75	0.85	1.68	0.83	0.64	0.80
Firm size	6.74	2.04	6.86	2.00	6.42	2.13	2.81	0.00
Global scope	7.00	8.55	7.51	8.66	5.79	8.17	2.49	0.00
Managerial obstacles	1.83	0.66	1.82	0.65	1.84	0.69	0.61	0.86
Competition intensity	2.72	1.14	2.69	1.15	2.80	1.09	1.16	0.13
Regulatory environment	1.46	0.82	1.48	0.83	1.38	0.77	1.09	0.19

the sample distributions of the two groups (Ryans 1974). A nonsignificant K-S test suggests that the sample distributions of the two independent groups do not differ statistically (Ryans 1974). As shown in Table 2, the K-S test for each factor is nonsignificant, with only two exceptions—firm size and global scope. Because these two items represented objective characteristics of a firm and answers to them were less likely to be influenced by subjective opinions, we concluded that positions of the respondents did not cause significant biases.

4.2. Measures

Measurement items were developed based on a comprehensive review of the literature as well as expert opinion. To facilitate cumulative research, operationalizations tested by previous research were used as much as possible, such as those for technology readiness, firm size, adoption, and competition intensity (Zhu et al. 2004, Zhu and Kraemer 2005). Other constructs were designed specifically for this study, including technology integration, global scope, and managerial obstacles. Below, we describe how each construct was operationalized, with more detailed definitions listed in the appendix available on the *Management Science* website (http://mansci.pubs.informs.org/ecompanion.html).

Dependent Variables. (1) A potential adopter's major task at the initiation stage is to gather relevant information about an innovation and evaluate its potential benefits (Thompson 1965, Rogers 1995). Thus, *E-Business Initiation* was measured by how the potential benefits of e-business were rated before the firm began using e-business. Four items were used: cost reduction, market expansion, entering new businesses, and supply chain coordination. (2) *E-Business Adoption* was measured by an aggregated index: whether the firm had used the Internet for each of the seven value chain activities. Other studies used a similar approach to measure the adoption of open systems (Chau and Tam 1997) and software practice technologies (Fichman 2001). The seven items, ranging from marketing, sales, and after-sales services to procurement and supply chain coordination, were designed based on the value chain model (Porter 1985). Then, we aggregated the seven adoption items to form our dependent variable, *e-business adoption*. This approach has been suggested by the literature to enhance the comprehensiveness of adoption measurement (Grover and Goslar 1993, Fichman 2001). (3) *E-Business Routinization* was measured by the extent of organizational usage of e-business to support value chain activities (Chatterjee et al. 2002). This was operationalized by the percentages of total sales to consumers/businesses, total services to consumers/businesses, and total procurement that were conducted on the Internet. Together, these items reflect the extent to which e-business has been incorporated into value chain activities.

Independent Variables. (1) *Technology Readiness* was measured by three items: (a) total number of personal computers; (b) related technologies used in the firm, e.g., EDI, EFT, intranet, and extranet; and (c) total number of IT professionals (Zhu et al. 2004). The first two items represent the penetration of traditional information technologies, which formed the technological infrastructure for newer e-business applications (Kwon and Zmud 1987). The third item represents IT human resources (Mata et al. 1995). This operationalization of technology readiness is consistent with the economic approach to decomposing IT resources into technologies in use and the number of IT professionals (Lichtenberg 1995). Using the number of IT professionals (as a percentage of the total number of employees) is based on the method used by Bresnahan et al. (2002). (2) *Technology Integration* was measured by the extent to which Internet systems are connected with back-office information systems and databases, and the extent to which company databases are linked to business partners' systems and databases. The measure was designed specifically for this study, but consistent with prior research on backend integration (Zhu and Kraemer 2002, 2005).

(3) *Firm Size* was measured by the number of employees in the organization, log-transformed to reduce data variation (Meyer and Goes 1988). (4) *Global Scope* was measured along two dimensions—geographic scope and trading globalization. *Geographic scope* was reflected by three items indicating geographic expansion of operations; *trading globalization* was reflected by the percentages of total sales and purchases from international markets (Zhu et al. 2004). (5) *Managerial Obstacles* were operationalized by three items—the difficulty of making organizational changes, integrating e-business into the overall strategy and business process, and acquiring expertise for e-business. These items (process change, IT strategic alignment, technology skills) are conceptually consistent with our earlier discussion of major obstacles in organizational adaptations; they are also empirically supported by previous studies (Chatterjee et al. 2002, Barua et al. 2004).

(6) *Competition Intensity* was measured by three items reflecting the degree of rivalry to which the firm was affected by competitors in local, national, and international markets (Porter 1985, Zhu et al. 2004). (7) Finally, based on a comprehensive study that analyzed the national environments and policies for e-business diffusion (Zhu et al. 2006b), we designed four items to measure *Regulatory Environment*: the extent that business laws support e-business transactions among firms; the legal protection of consumers' purchases on the Internet; the degree to which the use of e-business at firms was driven by incentives provided by the government and was required by government procurement. These items correspond to the three key areas in which government regulations and policies can encourage e-business assimilation, as discussed earlier (Kraemer et al. 2006).

5. Data Analysis and Results

We conducted a two-step data analysis to first assess the measurement model and then test the hypotheses by fitting the structural model. In this study, covariance-based structural equation modeling (SEM), as implemented in AMOS 4.0, was chosen primarily because of its emphasis on the overall variance-covariance matrix and the overall model fit (Fornell and Bookstein 1982). Because our research is aimed at testing the three-stage model and the TOE framework as a whole, covariance-based SEM is appropriate. We examined all of our model constructs and believed that they are reflective in nature. Also, our large sample size satisfies the requirement of the covariance-based algorithm.

5.1. Results of the Measurement Model

We performed successive runs of confirmatory factor analysis and refinement. We also assessed construct reliability, convergent validity, discriminant validity, and validity of the second-order construct, as reported in Table 3.

Construct reliability measures the degree to which items are free from random error, and therefore yield consistent results. In our measurement model (Table 3), most constructs have a composite reliability in excess of 0.70, implying acceptable levels of reliability (Fornell and Larcker 1981). *Convergent validity* assesses the consistency across multiple constructs.

Table 3 Results of the Measurement Model

Constructs	Range of standardized loadings†	Composite reliability	Correlation matrix									
			(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) Initiation	0.52–0.82	0.77	***0.69***									
(2) Adoption	*na*	*na*	0.32***	*na*								
(3) Routinization	0.41–0.76	0.71	0.35***	0.38***	***0.56***							
(4) Technology readiness	0.52–0.69	0.65	0.22***	0.32***	0.40***	***0.62***						
(5) Technology integration	0.53–0.92	0.73	0.35***	0.34***	0.42***	0.48***	***0.77***					
(6) Firm size	*na*	*na*	0.11***	0.12***	0.05	0.36***	0.15***	*na*				
(7) Global scope	0.52–0.95	0.72	0.18***	0.10***	0.12***	0.41***	0.25***	0.45***	***0.75***			
(8) Managerial obstacles	0.65–0.69	0.71	0.24***	−0.01	0.08**	−0.06	−0.02	0.03	0.06	***0.67***		
(9) Competition intensity	0.57–0.90	0.72	0.19***	0.03	0.01	0.10***	0.12***	0.02	−0.02	0.16***	**0.75**	
(10) Regulatory environment	0.72–0.75	0.70	0.42***	0.09***	0.15***	−0.01	0.11***	0.03	0.17***	0.31***	0.09***	***0.73***

na. Loadings, composite reliability, and Average Variance Extracted are not applicable to the single-item constructs.
$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$. †All standardized loadings are significant at $p < 0.01$ level.

As shown in Table 3, all estimated standard loadings are significant ($p < 0.01$) and of acceptable magnitude, suggesting good convergent validity (Sethi and King 1994). *Discriminant validity* refers to the extent to which different constructs diverge from one another. To test discriminant validity, we used Fornell and Larcker's (1981) criteria: The square root of the Average Variance Extracted (diagonal elements of the correlation matrix in Table 3) should be greater than the absolute value of interconstruct correlations (off-diagonal elements), suggesting that the items share more variance with their respective constructs than with other constructs. As shown in Table 3, all of our constructs meet this criterion. Global scope was modeled as a second-order construct with two first-order constructs: geographic scope and trading globalization. The efficacy of the second-order construct was assessed by the Target coefficient (T ratio) with an upper bound of 1 (Marsh and Hocevar 1985). Our model has a high T ratio of 0.95, implying that the relationship among first-order constructs is sufficiently captured by the second-order construct (Marsh and Hocevar 1985). In summary, our measurement model satisfies various reliability and validity criteria. Thus, constructs developed by this measurement model could be used to test the conceptual model and the associated hypotheses.

5.2. Results of the Structural Model—Full Sample

The standardized paths in the structural model are shown in the first three columns in Table 4, and several model-fit indices are shown in the bottom rows. These fit indices are all above the suggested cutoff of 0.9 (Barua et al. 2004), indicating a good model fit. The three dependent variables—e-business initiation, adoption, and routinization—have R^2 (square multiple correlation) of 29%, 39%, and 35%, respectively, which are deemed acceptable. After examining model fit and data variation explained, we proceeded to test each individual hypothesis by examining the magnitude and significance of its standardized path.

Within the technological context, we found that technology readiness has significant ($p < 0.01$) and positive paths to initiation, adoption, and routinization. Moreover, its paths to adoption and routinization have a higher magnitude than its path to initiation, with the difference (0.47 and 0.48 vs. 0.20) being statistically significant ($\chi^2 = 161.17$, $p < 0.01$). We also found significant ($p < 0.01$) and positive paths from technology integration to initiation, adoption, and routinization. Thus, the two hypotheses within the technological context, Hypotheses 1 and 2, are supported.

Within the organizational context, firm size has a significant but negative path to routinization ($p < 0.01$), as hypothesized earlier. However, it has a significant and negative path to adoption ($p < 0.01$). Thus, Hypothesis 3 is only partially supported because we proposed a positive relationship between firm size and adoption. All three paths associated with global scope are nonsignificant, so Hypothesis 4 is not supported. Managerial obstacles have significant and negative paths to initiation ($p < 0.01$) and rou-

Table 4 **Results of the Structural Model: Full Sample and Sample Split**

	Full sample ($N = 1{,}857$)			Developed countries ($N = 1{,}003$)			Developing countries and NICs ($N = 854$)		
	Initiation	Adoption	Routinization	Initiation	Adoption	Routinization	Initiation	Adoption	Routinization
Technology readiness	0.20*** (6.16)	0.47*** (13.25)	0.48*** (10.08)	0.04 (0.46)	0.29*** (4.14)	0.18** (1.98)	0.30*** (4.90)	0.69*** (10.39)	0.78*** (7.77)
Technology integration	0.25*** (6.75)	0.33*** (9.53)	0.32*** (7.20)	0.39*** (4.88)	0.25*** (3.67)	0.36*** (4.11)	0.14*** (2.85)	0.32*** (6.89)	0.30*** (4.73)
Firm size	−0.02 (−0.52)	−0.12*** (−3.06)	−0.14*** (−2.78)	−0.15** (−2.15)	−0.13** (−2.31)	−0.13* (−1.70)	0.03 (0.37)	−0.26*** (−3.53)	−0.35*** (−3.60)
Global scope	−0.03 (−0.06)	0.03 (0.07)	−0.01 (−0.20)	0.16** (2.04)	0.06 (1.02)	−0.03 (−0.35)	−0.17* (−1.88)	−0.08 (−0.96)	0.03 (0.14)
Managerial obstacles	−0.14*** (−4.29)	−0.02 (−0.50)	−0.08** (−2.12)	−0.16*** (−3.51)	−0.03 (−0.84)	−0.04 (−0.77)	−0.11** (−2.26)	−0.05 (−1.19)	−0.16*** (−2.65)
Competition intensity	0.10*** (3.62)	0.04*** (2.64)	−0.06** (−1.79)	0.15*** (3.87)	0.06** (2.04)	0.03 (0.50)	0.03 (0.07)	−0.10** (−2.21)	−0.22*** (−3.73)
Regulatory environment	0.34*** (8.80)	0.03 (0.74)	0.10*** (2.59)	0.18*** (3.28)	0.02 (0.81)	0.05 (0.89)	0.34*** (5.92)	0.14*** (2.76)	0.10* (1.69)
χ^2 (p-value)	2,937.47 ($p = 0.00$)			1,763.03 ($p = 0.00$)			1,334.58 ($p = 0.00$)		
R^2 (%)	29	39	35	34	41	22	24	46	56
NFI, RFI, IFI, TLI, CFI	0.95–0.97			0.95–0.96			0.96–0.98		
RMSEA (p-value†)	0.062 ($p > 0.10$)			0.062 ($p > 0.10$)			0.056 ($p > 0.10$)		

***$p < 0.01$; **$p < 0.05$; *$p < 0.10$. T-statistics are shown in parentheses.
†P-value for the test of a fair model fit (RMSEA < 0.08).

tinization ($p < 0.05$), and thus Hypothesis 5 is partially supported.

Within the environmental context, competition intensity has significant and positive paths to initiation ($p < 0.01$) and adoption ($p < 0.01$), yet a significant and negative path to routinization ($p < 0.05$). These results provide strong support for Hypothesis 6, wherein we proposed differential effects of competition across the three assimilation stages. Finally, regulatory environment has significant and positive paths to initiation ($p < 0.01$) and routinization ($p < 0.01$). Thus, Hypothesis 7 is partially supported.

5.3. Results of the Structural Model—Sample Split

Our survey included developed countries as well as developing and newly industrialized countries (NICs). This afforded us a unique opportunity to examine the role of national environments on e-business assimilation. National environment were evaluated along two dimensions: (1) aggregated IT investment as a percentage of GDP, and (2) GDP per capita (Zhu and Kraemer 2005, Dewan and Kraemer 2000). According to these two dimensions, the 10 economies in our sample can be categorized into two distinct groups: (1) developing countries and NICs (Brazil, China, Mexico, Singapore, Taiwan), $N = 854$, and (2) developed countries (Denmark, France, Germany, Japan, United States), $N = 1{,}003$. We then ran structural equation modeling on each subsample respectively. The results are shown in Table 4. Again, we evaluated our model in terms of fit indices and R^2s.

In the developed-country subsample, we found that technology readiness and technology integration are significant factors for each assimilation stage, except that the path from technology readiness to initiation is nonsignificant. Relatively speaking, *technology integration* is more significant than technology readiness (in terms of the relative magnitude and significance of standardized paths). Firm size is a significant and negative factor at each of the three stages. Scope is positive for initiation, but nonsignificant for adoption and routinization. We also found partial support for our hypotheses that competition intensity and regulatory environment facilitate initiation, while managerial obstacles inhibit e-business initiation (in comparison, firms in developing countries suffer even more from managerial obstacles).

In the developing-country subsample, we discovered different relationships. We found that, while both technology readiness and technology integration have significant, positive effects, *technology readiness* is more significant than technology integration. This result contrasts sharply with the developed-country subsample. We also found a significant, positive role played by the regulatory environment at each of the three stages, which is much stronger than in developed countries. Firm size and managerial obstacles remain negative, but more so in developing countries than in developed countries, indicating the extra challenges faced by firms in developing countries. These different relationships between the two subsamples provide support for Hypothesis 8.

6. Discussion

6.1. Major Findings

Using a unique international data set, we tested the effects of seven TOE factors on three stages of e-business assimilation. The empirical results have revealed several factors that have differential effects at different stages and in different environments. Below, we discuss these results as framed by the TOE contexts.

Technological Context. *First, while technology readiness is the strongest factor in developing countries, technology integration becomes the strongest factor in developed countries, suggesting that as e-business evolves, the key determinant of e-business assimilation shifts from accumulation of individual technologies to* integration *of these technologies*.

Within the technological context, both technology readiness and technology integration are positive factors for e-business assimilation in both developed and developing countries, but their relative importance is different across the two subsamples. In developing countries, *technology readiness* is most critical among all seven factors, suggesting that basic technology infrastructure is still highly important for e-business assimilation in developing countries. In contrast, *technology integration* becomes the strongest factor in developed countries. It might be argued that firms in developed countries tend to be more advanced in using information technologies, and as common technologies become "strategic necessities," firms need to pursue deeper usage of IT. One example of such deeper usage is to integrate disparate systems and reduce incompatibility between existing IS applications (Zhu and Kraemer 2005). Our results show this to be the strongest factor facilitating e-business assimilation in developed countries. Developed and developing countries seem to be at different stages of e-business transformation (Kraemer et al. 2006, Zhu et al. 2004). Thus, this difference suggests that, as e-business evolves, the key determinant of e-business assimilation shifts from the use of common technologies to deeper strategies to deploy them, especially technology integration that helps to leverage existing information and data resources across key processes along the value chain (Zhu and Kraemer 2005).

Organizational Context. *Second, large firms are less likely to achieve e-business routinization, suggesting that possible structural inertia associated with firm size may retard e-business transformation*.

Within the organizational context, our study reveals a negative effect of firm size on e-business assimilation, particularly the routinization stage. E-business routinization requires concerted efforts to mutually adapt corporatewide information systems, organizational structures, and business processes (Devaraj and Kohli 2003, Zhu et al. 2004). As discussed earlier, large firms are often burdened by structural inertia due to fragmented legacy systems and entrenched organizational structures, which may retard their digital transformation. Moreover, successfully assimilating e-business into the value chain requires that senior executives, business managers, and IS managers interact regularly to achieve tight collaboration (Chatterjee et al. 2002). Along this line, small firms may have an advantage because they "require less communication, less coordination, and less influence to gather support" (Nord and Tucker 1987, p. 18).

This result is consistent with previous research on software practices (Zmud 1982) and CASE technologies (Purvis et al. 2001). These prior studies found a negative effect of firm size at the routinization stage. To explain why large firms were less likely to routinize software practices, Zmud (1982) argued that "the size effect seems more complex with a possible explanation being that larger software groups require more software managers and that this larger decision body would experience difficulty in making administrative adoption decisions and in implementing those decisions." This argument is consistent with the notion of "structural inertia."

Furthermore, this negative effect may be even more significant in the e-business context. E-business represents a corporate-level innovation embedded in mainstream businesses (Zhu and Kraemer 2005). These features are in contrast to innovations such as software practices and CASE technologies that are restricted within the IT functional areas (Swanson 1994). Thus, organizational restructuration and process reengineering required by e-business routinization involves the coordination among more departments and the redesign of more processes, and thus might be more complex (Chatterjee et al. 2002). As a result, the structural inertia—reflected in organizational adaptations—tends to be more pronounced for e-business routinization, as evident from our empirical results.

Yet, it is surprising that firm size also plays a negative role at the adoption stage. It is common knowledge that large firms have more slack resources for committing required investments (Rogers 1995). One plausible explanation is that our model has controlled for technological and managerial resources, and, thus, the net effect of firm size in our model might be dominated by structure inertia. To test this explanation, we examined correlations between firm size and e-business initiation, adoption, and routinization (shown in Table 3). Clearly, without controlling for various firm resources, firm size is positively related to initiation ($\rho = 0.11$, $p < 0.01$) and adoption ($\rho = 0.12$, $p < 0.01$). Thus, combining the correlation analysis and the SEM results, our study suggests that the net effect of firm size is negative, representing a tension between resource advantages and structural inertia.

Previous studies identified different roles of firm size in IS assimilation, such as a positive effect at the adoption stage (Zhu et al. 2003) and a negative effect at the routinization stage (Zmud 1982, Purvis et al. 2001). But, these studies have not provided much support for the notion of "differently directioned effects," because the different innovations and separate research designs made it difficult to explain the results of these studies as a whole (Fichman 2000). In this regard, our study contributes to the literature by showing empirical evidence at three assimilation stages in a unified model, thus advancing a theoretical view on the size effect (resources advantages versus structural inertia).

Third, the negative effect of global scope on e-business routinization is mitigated by technology integration, suggesting that technological capability and firm structure interact and jointly affect innovation assimilation.

The results shown in Table 4 do not support our hypothesis on global scope. In the full sample, global scope is nonsignificant at each of the three stages, which is indeed surprising given the widely cited relationship between scope and IT investment (Gurbaxani and Whang 1991). To probe deeper into this factor, we tested its interaction with technology integration. This further test is motivated by the theoretical argument that greater technology integration tends to lead to better corporatewide information flows (Goodhue et al. 1992). Thus, the negative effect associated with greater scope—increased complexity of corporatewide coordination in process reengineering and organizational restructuring (Damanpour 1996)—may be mitigated by technology integration. We expect the interaction effect to be significant at the routinization stage, because routinization necessitates organizational changes in processes and structures (Cooper and Zmud 1990).

We performed hierarchical regressions of routinization against technology integration and global scope, as well as their multiplication (Table 5). Without the multiplicative term, the regression model had a similar result as SEM; with the multiplicative term, however, the regression model showed a strong, significant interaction effect ($b = 0.14$, $p = 0.056$). Global scope is positively linked to e-business assimilation only if it is coupled with a high degree of technology integration. Otherwise, broader scope and fragmented systems might slow down e-business assimilation. This seems to suggest that, to sufficiently capture the benefits of Internet innovations in facilitating transactions, it is particularly important for firms with greater scope to develop e-business capabilities such as the ability to integrate various IS applications. Anecdotal evidence suggests that e-business leaders such as Dell, Cisco, and Siemens develop a high degree of integration of their information systems. Such integration capability improves their effectiveness in using the Internet technologies to support operations in an extensive global scope. This finer-grained result may explain why the main effect of global scope by itself is nonsignificant in the full sample. At a more fundamental level, it is consistent with the view that *technological capability and firm structure may interact to reinforce the effectiveness of innovation assimilation*.

Environmental Context. *Fourth, competition positively affects e-business initiation and adoption, but negatively impacts routinization, suggesting that too much competition is not necessarily good for technology assimilation because it drives firms to chase the latest technologies without infusing existing applications*.

Prior studies on technology diffusion have found that competitive pressure increases a firm's incentives to seek new technology innovations so as to maintain a competitive edge (Kamien and Schwartz 1982, Iacovou et al. 1995). Our study shows that when firms face strong competition, they tend to adopt e-business more aggressively, a finding consistent with the conventional wisdom (Kamien and Schwartz 1982). Yet, its effect on the deeper stage (routinization) is surprisingly different. The negative relationship between competition and routinization seems to suggest that competition may detract firms from learning how to use existing e-business applications effectively, by driving them to chase the latest technologies (Abrahamson 1991). A new technology such as e-business becomes effective only through gradual, careful, and sustained assimilation processes that provide organizations with tacit knowledge and the managerial skills necessary to implement the technology efficiently. However, too much competitive pressure drives firms to leap rapidly from one innovation to the next without sufficient time to infuse the innovation into the organization. This result suggests that *too much competition is not necessarily good for technology assimilation*. This result challenges the conventional wisdom about competition and innovation diffusion (Kamien and Schwartz 1982, Williamson 1983).

Table 5 **Interaction between Technology Integration and Global Scope**

	Routinization	Routinization
Technology integration	0.39*** (5.22)	0.39*** (5.32)
Global scope	−0.01 (−0.13)	−0.02 (−0.30)
Technology integration × global scope		0.14* (1.93)
F	13.71***	10.54***
R^2 (%)	15.0	17.0
Adjusted R^2 (%)	13.9	15.4

Notes. Table entries are standardized regression coefficients.
T-statistics are shown in parentheses. ***$p < 0.01$; **$p < 0.05$; *$p < 0.10$.

Cross-Country Effects: Firms in Developed vs. Developing Countries. *Fifth, economic environments shape innovation assimilation because significant differences exist across developed and developing countries. In particular, regulatory environment plays a more important role in developing countries than in developed countries*.

Comparing the developed and developing samples, we found that government regulation is more important for e-business assimilation in developing countries. Compared to developed countries (Zhu et al. 2003) most developing countries have different market environments, characterized by information asymmetry, imperfections, and immature institutional structure. As pointed out by Zhu et al. (2004, p. 44), "government regulation (e.g., regulating monopoly power and dealing with e-business fraud) tends to play a greater role in developing countries. Furthermore, government interventions are in general more frequent in developing countries and NICs, such as China, Singapore, and Brazil." These factors make firms in developing countries regard government regulation as a more important factor. Together with the differential effects of other factors discussed earlier (e.g., technology readiness, technology integration, managerial obstacles) across developed and developing countries, this finding confirms that *economic environments shape innovation assimilation*. This also suggests that careful attention should be paid to the differential effects of innovation assimilation across developed and developing countries (Zhu et al. 2006b).

6.2. Limitations and Future Research

Our methodology required trade-offs that may limit the use of the data and interpretation of the results. Below, we discuss the key limitations of this study and corresponding avenues for further research.

First, due to our data set being cross-sectional in nature, we can only show associations, not causality, and we cannot analyze longitudinal processes, such as the evolution of technology integration and the assimilation process in a dynamic context (Zhu et al. 2004). After the burst of the dot-com bubble, we have witnessed changes in corporate strategies and business models for e-business (Geoffrion and Krishnan

2003). This means that the phenomenon we are studying is changing while in the very process of studying it. Future research needs to conduct new rounds of survey to pave the way for longitudinal research. By comparing data collected at different periods, more insights could be gained about the assimilation process of e-business in a dynamic environment.

A second limitation in our survey is the use of single respondents. Although we compared IS and non-IS managers and found no significant differences in their responses to both technology questions and business questions, we recommend that future studies, whenever feasible, collect data from both an IS manager and a business manager at each firm. This will be challenging to implement, but data from multiple respondents can be useful to further test the validity of our model.

Third, like many survey studies in the IS literature, measurement instruments are not "set in stone." Instead, developing solid instruments for studying e-business is still an ongoing process of development, testing, and refinement (Zhu and Kraemer 2002). Although construct reliability and validity were empirically tested in our data set, future confirmatory studies are necessary to determine the external validity of the results. In particular, the construct of global scope needs to be enriched in further research to include product scope and functional scope. Because of the significant role of technology integration shown in this study, future research may tap into specific questions about how firms integrate the Internet with back-office systems such as ERP, supply chain, and customer relationship management. The measurement for IT human resources can also be improved. Future research can add questions about IT professionals' experience and skills with e-business-related technologies. Finally, to improve the measures for managerial obstacles, future research can ask managers' capabilities of adapting structures and processes in a dynamic environment, thus better capturing managerial capabilities of change management.

6.3. Managerial Implications

Our study provides several important implications for managers. First to ensure smooth implementation and routinization, firms need to build up technological capabilities by integrating various IT components into a streamlined system, based on essential e-business-related infrastructure and human resources. Top managers should put a high priority on *integrating fragmented technologies* and linking those "islands of automation" to support key information processes across the value chain. At the same time, realizing the full economic potential of technology integration requires the necessary organizational reconfiguration and business processes reengineering (Fichman 2000, Devaraj and Kohli 2003). As Internet technologies diffuse and become necessities, such capabilities will become even more critical. In addition, diversified firms need to pay even more attention to technology integration. For example, both Hewlett-Packard and Cisco initially pursued different technologies within the company, but quickly realized that common standards, processes, and methods were needed (Wargin and Dobiey 2001). Otherwise, the global scope of such large firms and their fragmented systems can only slow down e-business assimilation.

In addition, this study suggests that managers need to adjust *management practices* at different assimilation stages. For instance, at the initiation stage, large firms tend to enjoy resource advantages, but they have to overcome structural inertia in later stages. Thus, when migrating business activities onto the Internet platform, large firms need to pay special attention to change management issues (Roberts et al. 2003). Perhaps most important is the *change model* that is used—whether the traditional three-stage planned change model—"unfreezing, change, refreezing" (Kwon and Zmud 1987)—or a more improvisational model (Orlikowski and Hofman 1997). The planned change model is appropriate for well-understood technologies and for organizations whose environments and functionality are relatively stable such that a systematic and structured approach is possible. The improvisational model is appropriate for technologies that are more open-ended and for organizations in more uncertain environments where assimilation requires a fast, flexible approach (Orlikowski and Hofman 1997). Especially in large organizations, e-business assimilation might require a mix of these two models with periods of improvisation followed by anticipated change, and then more improvisation, and so on in a virtuous chain.

This mixed approach fits well with the notion of assimilation stages in which firms might not only use different approaches to change management, but also organize differently for initiation and adoption than for routinization. Although we are unaware of systematic research on *organization for e-business*, there are cases and practitioner reports we can draw on. For example, at Hewlett-Packard (Wargin and Dobiey 2001), Dell (Kraemer et al. 2000), and Cisco (Kraemer and Dedrick 2002), early e-business activities were decentralized in a few business units that experimented with new uses of the Internet. The positive results encouraged wider adoption, sometimes with involvement of the IT unit (Cisco and Dell) and sometimes independently (HP). Such experimentation was (and still is) considered necessary and desirable by business and IT executives (Pastore 2001).

However, the new applications were usually developed quickly, without reference to existing IT standards or infrastructure. As the need arose to integrate these applications into the firm's core IT, it became apparent that a more systematic and coordinated approach was required. The firms then brought the business and IT units together to formulate standards for technical platforms and data integration, priorities for implementation, and phased plans for further e-business assimilation across the enterprise. Implementation (routinization) was carried out in some cases by IT and in other cases by the business units under centralized IT leadership. IT also provided the technical infrastructure and change management support, including communication, education, training, crisis teams, and monitoring to discover problems and opportunities that would enable them to recycle through the whole process (Wargin and Dobiey 2001, Kraemer and Dedrick 2002). As these and many other cases suggest, experimentation, open communication, organization flexibility (e.g., centralization and decentralization), and ongoing support are key management practices leading to successful assimilation of innovations.

A related implication arising from the findings and these examples is that e-business vendors, as the early adopters (and consultants to other early adopters), should share their change management experience with customers, given many of the vendors are themselves leaders in e-business assimilation. The technology's performance nearly always lags the vendors' promotion, so it is more important that vendors assist user companies with change management. When customers perceive difficulties in transforming value chain activities to the Internet, vendors should provide more technical support, training, and peer information, thus enhancing user satisfaction and innovation effectiveness.

Finally, our study offers implications for policy makers, particularly in developing countries. The *environment*—both regulatory and economic—has emerged as an important factor shaping innovations assimilation. This is particularly important in developing countries, but also very important at the initiation stage of e-business development in any economy. This points to the need for establishing a legal and institutional framework that supports e-business and online transactions (Kraemer et al. 2006). Our results also indicate that firms in developing countries suffer more from managerial obstacles than those in developed countries. For example, this includes how to integrate the Internet into business strategy, how to make needed organizational changes, and how to acquire staff with e-business expertise. This emphasizes the need for building IT managerial skills for the efficient usage and assimilation of innovations. One important means for firms in developing countries to acquire such skills is from e-business vendors whose interests in expanding markets are served by such transfer (Lee et al. 2004). Another is to work with foreign multinational corporations who benefit from transferring such skills either as a means of extending their markets or upgrading the e-business capabilities of local suppliers (Caselli and Coleman 2001). When transfer occurs to one supplier or partner in a developing country, it frequently spreads to others through worker mobility, industry promotion, or government assistance (Kraemer et al. 2006).

7. Conclusions

As contemporary firms increasingly seek to improve their performance in value chain activities by using the Internet, it becomes a significant undertaking for firms to assimilate e-business innovations to support customer services, revenue generation, procurement, information sharing, and coordination with suppliers. Hence, it is important to understand what factors influence e-business assimilation. Drawing upon theoretical perspectives on the process and contexts of innovation diffusion, we develop an integrative model to examine the influence of seven contextual factors on three stages of e-business assimilation. Our empirical results identified significant factors shaping the assimilation, and revealed their differential effects across different stages and in different environments.

This study makes three specific contributions to the literature on innovation assimilation. First, we conceptualized three stages (initiation, adoption, routinization) in innovation assimilation, and integrated the three-stage conceptualization with the technology-organization-environment framework. In previous studies, we showed the usefulness of the TOE factors for understanding single stages of e-business diffusion, such as a adoption decisions (Zhu et al. 2003), usage (Zhu and Kraemer 2005), and value (Zhu et al. 2004) across different industry sectors and economies. In this paper, we extend our previous work (and the general IT diffusion literature) by emphasizing the *process* of assimilation and by developing an integrative conceptual model (Figure 1). As such, the external validity of the integrative model tested in this work is enhanced by other related studies. Our previous work, however, only applied to the TOE framework to study single stages in the process of e-business diffusion. The different foci on different stages mean that they have different dependent variables. They are also based on different theories and tested in different industries with different results. More broadly, most of the existing studies in the literature examined innovation diffusion with an "adoption versus nonadoption" focus (Fichman 2000). In contrast, our process-oriented approach in this paper allowed us to examine the "differential effects" of TOE factors along the three stages of the diffusion process. This approach has not been used in the previous papers, to the best of our knowledge. Using e-business as an example of more general innovation assimilation, we tested the integrative model by a large data set of 1,857 firms in an international setting. As the results show its usefulness, this conceptual model can be used as a theoretical framework for studying other types of technological innovations such as wireless technologies and radio frequency identification (RFID).

Second, we theorized and tested differential effects of the TOE factors across the assimilation stages. Although prior research has recognized such differential effects as an important theoretical issue (Tornatzky and Klein 1982), the literature lacks empirical examination (Fichman 2000). To the best of our knowledge, this paper is the first systematic study of the differential effects in innovation assimilation. Our work documents the significance of this issue by revealing three finer-grained relationships: (1) a positive effect of competition on initiation and adoption, but a negative effect on routinization—competition may be detracting firms from ingraining the current technology (which is more severe in developing countries); (2) a mix of resource advantages (facilitating initiation and adoption) and structural inertia (retarding routinization) associated with firm size; and (3) the increasing importance of technology readiness at the adoption and routinization stages than at the initiation stage. These results support the theoretical notion of "differently directioned effects," that is, *the same factors may play different roles at different assimilation stages*. As the assimilation of a variety of technological innovations can be viewed from this process-oriented perspective, we believe that our results represent a significant theoretical and empirical advancement to the literature.

Third, by theorizing the international effects and developing a systematic approach to data collection in a multicountry context, this study extends an international dimension to innovation diffusion (Zhu and Kraemer 2005, Zhu et al. 2004). Based on the global data set, this study teases out several cross-country differences: (1) in developing countries, technology readiness is the most important factor for e-business assimilation among the seven TOE variables; (2) yet, in developed countries, technology integration becomes more important; (3) regulatory environment plays a more significant role in developing countries than in developed countries; and (4) firms in developing countries might be further detracted by managerial obstacles. The broad data set from developed, developing, and newly industrialized countries strengthens the generalizability of our findings. We hope our work will encourage more research in this important area.

An online supplement to this paper is available on the *Management Sciences* website (http://mansci.pubs.informs.org/ecompanion.html).

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