Assimilating IT Innovation: The Longitudinal Effects of Institutionalization and Resource Dependence

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ASSIMILATING IT INNOVATION: THE LONGITUDINAL EFFECTS OF INSTITUTIONALIZATION AND RESOURCE DEPENDENCE

Assimiler les innovations en matière de technologies de l'information : Effets longitudinaux de l'institutionnalisation et de la dépendance des ressources

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Abstract

This study seeks to understand the longitudinal effects of external pressures on the assimilation of IT innovations in organizations, making the distinction between pressures from organizations' exchange partners and pressures from the institutional environment. Analyzing 11-year survey data on the adoption and usage of enterprise resource planning (ERP) in Fortune 1000 companies, I have found significant evidences for both sources of external pressures for ERP assimilation. Further, the effects of pressures from exchange partners depended on the extent to which ERP was legitimated as an appropriate organizational technology and practice. These findings not only resolve the long-time confounding of institutional theory and resource dependence theory, but also help delineate each theory's applicability in the operation of external factors on IT assimilation. Practically, this research helps guide practitioners to prioritize external pressures and align such pressures with their organizations' internal specifics.

Keywords: Information technology innovation, assimilation, institutional theory, resource dependence theory, enterprise resource planning

Résumé

Cette étude vise à expliquer les effets longitudinaux des pressions externes sur l'assimilation des innovations en matière de technologies de l'information, distinguant les pressions exercées par les partenaires de l'organisation et celles exercées par l'environnement institutionnel. L'analyse des données issues d'une enquête sur l'adoption et l'utilisation des progiciels de gestion intégrés (PGI), par des entreprises classées dans Fortune 1000, montre l'existence des deux sources de pression externe pour l'assimilation des PGI.

摘要

本文探讨外部因素对企业运用新的信息技术的长期影响。文章对源于交易伙伴的压力和源于制度环境的压力加以区别。对美国财富一千强企业十一年来运用ERP的数据分析有助于厘清体制理论和资源依赖理论各自的适用范围。

Introduction

By now many companies worldwide have already implemented the RFID (radio frequency identification) technology. They are working on assimilating RFID into their day-to-day supply chain operations, seeking to improve the efficiency of inventory management and thus satisfy their customers and suppliers. At the same time, some of these companies have also set up stores in Second Life. Many early adopters of Second Life, however, take a wait-and-see approach without assimilating their virtual stores into their routine business processes, despite the widespread enthusiasm about Second Life in the media. The practical challenge here is: with a potentially limitless number of new information technologies (such as RFID, Second Life, and numerous others) promoted by many actors in the environment and limited resources and attention available, which innovation(s) should a firm choose to assimilate and when and how to do so? More specifically, how do firms assimilate IT innovations into their internal operations and processes under the external pressures from both their exchange partners (e.g., investors, suppliers, and customers) and the institutional environment (i.e., social conditions such as competition, industry standards and association, and laws and regulations)?

In innovating with IT, an organization comprehends, adopts, implements, and assimilates the innovations (Swanson and Ramiller 2004). Assimilation is defined as the extent to which the new IT is used and becomes routinized in the activities of the organizational projects or work processes (Purvis et al. 2001). Assimilation is important because it is the process by which the potential business value of the IT innovation may be eventually realized (Armstrong and Sambamurthy 1999). Assimilation is often problematic because the support and attention summoned for adoption and implementation usually fade away after implementation and the individual and organizational learning required for assimilation often takes time to accomplish (Armstrong and Sambamurthy 1999). Despite the importance of and problems with assimilation, research on IT assimilation is scarce and sporadic (Swanson 2004).

Most of the few studies on assimilation treat it as primarily a process *internal* to each organization. For instance, it has been found that characteristics and processes of organizational internal dynamics such as user training and top management support affect assimilation (e.g., Agarwal et al. 1997; Cho and Kim 2002). However, recent research has shown that the assimilation of an IT innovation is subject to pressures emanating from *outside* the adopting organizations, indicating that assimilation is not entirely an internal process (Liang et al. 2007). This interesting finding breaks important new ground – the effects of external dynamics on the assimilation of IT innovations. Much remains to be explored about the operation of external factors on assimilation. Theoretically, since numerous forces and processes exist in an organization's external environment, research must explain *what external factors influence and when they influence IT assimilation*. Empirically, studies must be designed to differentiate various external factors and demonstrate their effects on assimilation over time.

Presently, neither theoretical development nor empirical testing in IT innovation research is well prepared for such exploration. On the theoretical side, theories focusing on external factors have been frequently applied to studying pre-assimilation activities, but rarely to studying assimilation. For example, IT innovation researchers customarily

employ institutional theory to explain the effects of an organization's institutional environment on the comprehension, adoption, and implementation of various IT innovations (e.g., Christiaanse and Huigen 1997; Teo et al. 2003). Seldom do they explore such effects on assimilation (Liang et al. 2007). Our knowledge is inadequate as to whether these theories hold for assimilation, and if not, what theories we may find or build to explain the effects of external factors on assimilation. On the empirical side, extant studies on IT assimilation did not differentiate between pressures from an organization's institutional environment and pressures from its exchange partners. This practice constrains the relevance of assimilation research to practitioners who strive to prioritize their efforts to distinguish and address various external pressures. Further, as the prevailing form and intensity of external pressures change over time, assimilation studies currently dominated by cross-sectional analysis fall short of showing the evolving long-term effects.

Addressing these theoretical and empirical challenges and using ERP (enterprise resource planning) as an example of IT innovations, this study seeks to understand the longitudinal effects of external pressures on the assimilation of ERP in organizations, making the distinction between pressures from organizations' exchange partners and pressures from the institutional environment. Analyzing 11-year data from IDC (International Data Corporation) annual surveys on the adoption and usage of ERP in *Fortune 1000* companies, I have found significant evidences for both sources of external pressures for ERP assimilation. Further, the effects of pressures from exchange partners depended on the extent to which ERP was legitimated as an appropriate organizational technology and practice.

The study makes several contributions to theory development and empirical investigation of IT assimilation. Most conspicuously, the study's longitudinal dataset makes it possible to examine the assimilation process unfolding over time, complementing insights gained from studying assimilation using cross-sectional data. Further, the study validates the research strategy to examine both external and internal factors on assimilation, corroborating that assimilation is not just an internal, closed process. Moreover, the study differentiates organizations' broader institutional environment from their exchange partners and integrates institutional theory and resource dependence theory. The key insight is that exchange partners' influence on assimilation depends on the degree of the innovation's institutionalization among and beyond these partners. This finding not only resolves the long-time confounding of institutional theory and resource dependence theory, but also helps delineate each theory's applicability in the operation of external factors on IT assimilation. Practically, this research helps guide practitioners to prioritize external pressures and align such pressures with their organizations' internal specifics.

Theoretical Foundation

Information Technology Innovation

For the last two decades, the topic of *information technology innovation* has elicited proliferating empirical studies and enduring interest in Information Systems research. An IT innovation is the organizational application of digital computer and communications technologies commonly known as information technology, or IT (Swanson 1994). The diffusion of an IT innovation is the process by which the focal IT spreads across and within organizations (Rogers 2003; Swanson and Ramiller 2004).

Attempting to explain why and how organizations innovate with IT, researchers often take a stage/phase approach to understand the process and outcomes of IT innovations (Cooper and Zmud 1990; Kwon and Zmud 1987; Zmud and Apple 1992). Recently, Swanson and Ramiller (2004) argued that an organizational IT innovation is a journey that involves four core processes: comprehension, adoption, implementation, and assimilation. First, organizations collect and interpret information from their environments about an IT innovation. Second, this comprehension effort informs organizations' decisions on whether to adopt or reject the innovation. Third, where adoption is in fact pursued, implementation brings the innovation to life – hardware and software are installed and configured, business processes are changed, users are trained, and so on. Finally, in due course the innovation becomes assimilated into routines in organizational work systems. In reality, these processes are engaged in overlapping and complex ways.

Despite the different terms that have been used to refer to the various stages, phases, or processes of IT innovations, most researchers seem to agree that innovation does not end with the completion of implementing the technology. To realize the full potential and value of the IT innovations, adopting organizations need to assimilate the new IT into its organizational routines, a process that may go on for a long time after implementation. Thus far, the majority

of IT innovation research has focused on events and activities pre- or during implementation (Swanson 2004). Research on IT assimilation has just emerged and is gaining increasing attention.

Information Technology Assimilation

The dictionary definitions of the word "assimilate" range from conversion of nutrients by plants and animals, to rendering a sound accordant, and to absorption or incorporation of a substance into a system (*Oxford English Dictionary*). In the latter sense of "absorption" or "incorporation," in this study I subscribe to Purvis et al.'s definition of technology assimilation – "the extent to which the use of the technology diffuses across the organizational projects or work processes and becomes routinized in the activities of those projects and processes" (Purvis et al. 2001, p. 121). This definition has several useful features. First, the emphasis on use is necessary because it is from the use of the technology that the essential individual and organizational learning and the ensuing organizational capabilities result (Armstrong and Sambamurthy 1999). Second, the use of a technology, especially in enterprisewide scale, requires implementation to be largely complete, so this definition has a clear focus on post-implementation activities. Third, the two core elements of the definition, i.e., the spread of use and the routinization of such use, do not conflated with the causes (e.g., top management support) or effects (e.g., business value realization) of assimilation, making the definition theoretically pure. Lastly, such theoretical precision makes it relatively straightforward to operationalize the definition in empirical studies.

There are a few other definitions of assimilation in the literature (see Swanson 2004 for an extensive review). Generally speaking, other definitions have broader scopes than Purvis et al.'s in one or two ways. For one, assimilation was used to denote more phases of an organization's innovation life cycle, more extensive than the "assimilation in use" I described above. For example, Meyer and Goes (1988) defined assimilation as "an organizational process that (1) is set in motion when individual organizational members first hear of an innovation's development, (2) can lead to the acquisition of the innovation, and (3) sometimes comes to fruition in the innovation's full acceptance, utilization, and institutionalization" (p. 897). This view was followed by Fichman and Kemerer (1997; 1999) and Cho and Kim (2002). Gallivan (2001) narrowed the focus to post-adoption activities, but still his definition of assimilation covers some implementation events broader than assimilation in use. For another, some definitions tend to include not only the process and outcome of assimilation, but also the consequences of assimilation. For example, Armstrong and Sambamurthy (1999) defined IT assimilation as "the effective application of IT in supporting, shaping and enabling firms' business strategies and value-chain activities" (p. 306).

Taking all of this into account, I believe that Purvis et al.'s definition provides a theoretical middle ground for advancing research on IT assimilation. It is both broad enough to accommodate various manifestations and processes of assimilation and focused enough to maintain distinction from related concepts. With a good definition for assimilation, I now turn to factors that affect assimilation.

Factors Affecting IT Assimilation

It has been argued that IT innovation research has converged to a dominant paradigm (Fichman 2004). Under the paradigm, a wide variety of organizational, technological, and environmental factors have been found affecting organizational IT innovations (Kwon and Zmud 1987). Interestingly, as the paradigm is populated mostly by studies of IT adoption and implementation, whether and to what extent these factors shape assimilation is still a good question for more research.

My review of the emerging research on IT assimilation has shown that the outcome and process of assimilation are affected by three types of factors: (1) the characteristics of the IT innovation, (2) the characteristics of the context in which the innovation is undertaken, and (3) the interaction between the innovation and the context. Despite the diverse definitions of assimilation in these previous studies, three interesting patterns have emerged. First, the impact of the interaction between an innovation and the innovating context on assimilation is inconclusive. Purvis et al. (2001) found that the compatibility of existing system development methodologies with the CASE (computer-aided software engineering) technologies positively influenced the assimilation of CASE. In contrast, Cooper and Zmud (1990) found that task-technology compatibility explained MRP (material requirements planning) adoption, but not its assimilation. Second, as has been found in the mainstream of IT innovation research (on adoption and implementation), characteristics of the innovation and *internal* factors of the innovating organization influence assimilation. These findings imply that factors affecting adoption and implementation may continue their effects in

assimilation. Lastly, in contrast to the numerous studies that show many external factors affecting IT adoption, only one study shows that external factors affect IT assimilation (Liang et al. 2007).

This contrast should not be surprising. After all, assimilation is the process for an organization to *internalize* the innovation. Nonetheless, organizations are open systems (Scott 2003) and organizational members' thinking and doing are subject to the influence of many factors outside the organizational boundary. For instance, as an increasing number of organizations choose to purchase or outsource packaged IT products and services rather than develop their own in house (Lacity and Willcocks 1998; Swanson 2003), organizational decisions and actions are increasingly subject to external authority and control (Zucker 1991). In this sense, Liang et al.'s (2007) study breaks important new ground for a potentially profitable research stream on external pressures for IT assimilation.

External Pressures for Assimilation

Liang et al. (2007) argued that pressures for assimilating ERP systems exist in organizations' external environment. The pressures are likely to come from the firms' customers, suppliers, competitors, industry association, and/or government regulations. To conceptualize external pressures for assimilation, Liang et al. (2007) properly applied institutional theory, a widely employed theory for understanding the complex relationship between organizations and their external environment. While quite a few adoption and implementation studies have provided strong support for institutional theory (e.g., Christiaanse and Huigen 1997; Teo et al. 2003; Wang 2006), the applicability of the theory to IT assimilation deserves some further discussion.

Institutional Theory and IT Assimilation

Institutional theory offers a rich and diverse conceptualization of IT innovations (Orlikowski and Barley 2001). In various expressions of the theory, a common theme is that the activities of developing and using IT are subject to social pressures, often from external sources such as production and user organizations, professions, and government agencies. Institutional pressures push individuals and organizations to take intentional or unintentional actions such as conforming to technology mandates, adopting popular innovations, and modifying practices to fit technology, all possibly leading to increased opportunities for social approval or legitimacy. Since the theory was introduced to IS research (e.g., King et al. 1994; Kling and Iacono 1989), a large number of studies have usefully applied institutional theory to understanding a wide range of IT innovation phenomena, such as sources of control over information system development decisions (e.g., Nicolaou 1999), IT innovation-based industry emergence and evolution (e.g., Currie 2004), community and organizational comprehension and sensemaking of innovations (e.g., Swanson and Ramiller 1997; 2004), adoption intentions and decisions (e.g., Teo et al. 2003; Wang 2006) and choices and problems in implementation (e.g., Christiaanse and Huigen 1997; Gosain 2004).

The majority of institutional research has thus far focused on the comprehension, adoption, and implementation of IT innovations. It has been argued that, throughout the lifecycle of an innovation, early adoptions are often based on organizational-specific factors, while later adoptions tend to follow taken-for-granted, institutional logic about what constitute legitimate practice (Tolbert and Zucker 1996). Theory development has only touched upon IT assimilation briefly. In a later paper, Swanson and Ramiller (2004) suspected that the consideration of institutional pressures may be increasingly replaced by the attention to organizational specifics (the kind of attention which they termed "mindfulness") as the depth of organizations' engagement with the IT increases. Interestingly, analyzing data from 77 firms in China, Liang et al. (2007) found that institutional pressures were saliently present in these firms' assimilation of ERP and that the top managers' helpful thoughts and actions channeled the institutional pressures. Specifically, the authors found evidence that some external pressures positively shape top managers' belief about and participation in the ERP assimilation process and that such belief and participation in turn positively affect ERP assimilation in use. This finding suggests that top managers mediate between external pressure and internal organizational dynamics. Following Liang et al. (2007), I argue that pressures from an organization's institutional environment may permeate the organizational boundary and push the organization to assimilate an IT innovation. I thus raise and test the first hypothesis.

Hypothesis 1:   *Higher pressures from the focal organization's institutional environment are related to higher extent of assimilation of an IT innovation.*

Further, this study addresses two ambiguities existing in present institutional theory of IT innovations. First, quite a few empirical studies employed DiMaggio and Powell's (1983) three mechanisms to understand the effect of

institutional pressures on IT innovations. According to DiMaggio and Powell (1983), *coercive* pressures come from the focal organization's legal or cultural expectations; *mimetic* pressures derive from uncertainty, which drives organizations to model themselves on others; and *normative* pressures stem from professional expectations. As Tolbert and Zucker (1996) argued, the dominant form and effects of these mechanisms vary according to the level of institutionalization – the extent to which the focal innovation is legitimated as an appropriate practice. At different levels, the primary sources of institutional pressures tend to vary and that variation is largely neglected by empirical investigations simply applying the three mechanisms (Tolbert and Zucker 1996). Such omission may make it hard to compare findings from different studies to inform theory development and guide practice. Cross-sectional studies now populating institutional research on IT innovations cannot capture the changing levels of institutionalization. Given this shortcoming, this study adds the temporal dimension so that the longitudinal effects of institutional pressures on IT assimilation can be accurately measured and shown. Specifically, mimetic pressures may be dominant at a low level of institutionalization where uncertainty about an IT innovation is high, but insignificant at a high level of institutionalization where uncertainty about the innovation drops.

Hypothesis 2a: *The effect of mimetic pressures on assimilation decreases over time, as the level of institutionalization of the IT innovation increases.*

On the other hand, as the IT innovation continues evolving and its institutionalization moves up levels, the institutional environment is likely to increasingly accept and even mandate the innovation. Accordingly, coercive and normative pressures in the forms of laws, regulations, and professional and industry standards, on adoption and assimilation are likely to increase.

Hypothesis 2b: *The effect of coercive pressures on assimilation increases over time, as the level of institutionalization of the IT innovation increases.*

Hypothesis 2c: *The effect of normative pressures on assimilation increases over time, as the level of institutionalization of the IT innovation increases.*

Second, as currently formulated and tested, institutional theory seriously confounds with resource dependence theory. If Organization A depends on Organization B for resources and thus complies with the expectations of Organization B, then such compliance can be explained by either institutional (coercive) pressure or resource dependence, blurring the boundary between the two theories. In this regard, extant research on IT innovation has examined the effects of resource dependence (mostly from a focal firm's exchange partners) under the three mechanisms of institutional effects. To possibly clarify this theoretical ambiguity, this study seeks an opportunity to differentiate between pressures from an organization's institutional environment and pressures from its exchange partners in assimilating IT innovations. To understand such differentiation, we must first assess the relevance of resource dependence theory to IT assimilation.

Resource Dependence Theory and IT Assimilation

Around the same time when a number of classic papers articulated the contemporary versions of institutional theory (DiMaggio and Powell 1983; Meyer and Rowan 1977; Zucker 1977), resource dependence theory (RDT) emerged as another important theory that explains the relationship between organizations and their external environment. The theory has three central themes (Pfeffer and Salancik 2003). First, external environment or the social context of organizations importantly shape the decisions made about various organizational issues. Second, although organizations are constrained by their environments, there are opportunities for organizations gain, at least temporarily, some autonomy and ability to pursue organizational interests. Third, dependence on external actors (especially the exchange partners such as suppliers and customers) is connected with internal organizational dynamics and power mediates the connection. These themes are pertinent to organizational IT innovations. Organizations make decisions to adopt new IT based on their own interests (Theme 2) and/or expectations from actors they depend on in the environment (Theme 1). Since new IT inevitably change the power structure inside the organizations (Markus 1983), the implementation and assimilation of the technology hinge on the internal power struggle (e.g., between customer services department and procurement department), which in part reflects the relative powers of external actors (e.g., customers vs. suppliers) (Theme 3).

In contrast to the volume of empirical IS research from the institutional perspective, there has been a dearth of studies applying RDT despite its relevance to IT adoption and assimilation. Among the few studies from the RDT perspectives, some attempted to understand how IS can be designed and used to support resource exchange relations

among organizations (e.g., Hart and Saunders 1998; Teng et al. 1995; Tillquist et al. 2002); others tried to explain how resource dependence affects formal and informal ways to manage IT operations (e.g., Rao et al. 2007). The lack of empirical interest in RDT in IT innovation research is in part due to its confounding with institutional theory as mentioned earlier. Empirically, resource dependence is often examined under the disguise of "coercive pressures" in institutional research.

Organizational theorists did make several attempts to resolve the confounding (Ingram and Simons 1995; Tolbert 1985). For example, studying the administrative structures of public and private universities, Tolbert (1985) found that variation in administrative structures is predicted by non-traditional sources of support (e.g., government funds for private universities or private donations for public universities). This result implies that dependency relationships themselves can be legitimated and institutionalized and when certain relationships are not institutionalized, increasing dependencies will be directly associated with administrative structures that help manage such special relationships. Although Tolbert (1985) achieved some integration of institutional theory and RDT, she was silent about the relationship between the two theories in the circumstances where dependency relationships are highly institutionalized. Numerous relationships, such as those with customers, suppliers, and investors, are taken-for-granted and thus institutionalized for a long time. In fact, institutionalized dependency relationships far outnumber those not institutionalized and thus Tolbert's theory integration may address the exceptions rather than the norms. Recognizing this problem, in this study I focus on the traditional, institutionalized dependency relationships, those with customers, suppliers, and investors and raise the following hypothesis about the impact of resource dependencies on IT assimilation.

Hypothesis 3:   *Higher pressures from the focal organization's exchange partners are related to higher extent of assimilation of an IT innovation.*

Methods

To test the hypotheses, I used the survey method. Since Hypothesis 2 is concerned with a temporal effect, a longitudinal dataset is needed on the assimilation of an IT innovation for a period in which institutionalization moved up levels. To my knowledge, IT innovation researchers have not collected primary longitudinal survey data in this scale probably because of resource constraints and the rapid pace in technological change. For these reasons, I resorted to suitable secondary data from IT research companies that collect and analyze market data for multiple types of IT products and services. I found and acquired an 11-year dataset from IDC annual surveys on ERP adoption and usage in *Fortune 1000* companies, and thus taking ERP as an example of IT innovations.

The ERP Innovation

Gartner Group introduced the concept "enterprise resource planning" in 1990. In 1992, market leader SAP launched a client-server based ERP package that quickly conquered the European and US markets. By the end of 1998, more than 60% of the *Fortune 1000* companies had implemented ERP core applications (Stein 1999). With expanding functionalities and new interfaces added, ERP packages quickly spread from large companies to midsize companies, from European and US markets to Asia Pacific and Latin America, from manufacturing and logistics companies to other vertical industries such as wholesale, healthcare, and banking. Since 2000, web-enabled applications have opened new market opportunities for ERP. ERP is becoming institutionalized (Kumar and van Hillegersberg 2000).

Data Collection

Since 1996, IDC has been conducting annual surveys among companies worldwide about their adoption and usage of ERP. The dataset I used was compiled from surveys between 1996 and 2006 among *Fortune 1000* companies – the 1,000 largest U.S.-based corporations (as measured by gross revenue) that make their financial data publicly available. Every year between September and December, IDC sends surveys to the COOs (chief operating officers) or equivalent business executives at these companies asking them to answer questions related to their experiences in adopting, implementing, and using ERP. The number of responses varies from year to year, ranging from 8.7% (in 1996) to 31.2% (in 2002). Non-response was because either that the firms surveyed had not adopted ERP or that the firms had adopted but were unwilling to respond. The likelihood for the former reason (non-adoption) decreases sharply as ERP quickly reached near full penetration into *Fortune 1000* companies. I used Chi-square tests to compare the responding and non-responding firms' number of employees, industry, revenue, and assets and found no

significant difference ($p > .05$) for data in all years. In the last ten rows of Table 1, the responding companies are profiled each year.

Operationalization

Because the survey was designed for other purposes at IDC, I only extracted items relevant to this study from the survey (see Appendix A at www.wam.umd.edu/~pwang/ICIS2008.pdf). For each theoretical concept such as assimilation and institutional pressures, I selected items that resemble those used in previous research.

Dependent Variable – Assimilation. I followed Liang et al. (2007), who in turn followed a number of prior studies of IT usage, to measure ERP assimilation with the percentage of the firm's business processes using ERP (Item 1 in Appendix A) and the number of functional areas using ERP (Item 2). While I did not have other items to indicate assimilation, the two items could reasonably signify assimilation. Also, since I did not have other latent constructs and the correlations between the two items on assimilation averaged .85 (with a range from .77 to .89), I normalized them and then aggregated the scores to an overall assimilation measure.

Independent Variables. Regarding the pressures from the focal firm's exchange partners, I selected three items to measure the impacts of expectations from investors, customers, and suppliers (Items 3-5). These measures were used by Liang et al. (2007) and previous research under the three institutional mechanisms that DiMaggio and Powell (1983) proposed. Due to the confounding of institutional theory and RDT discussed earlier, I simply used these items as independent variables without merging them into a higher-level construct, so that the effect of each type of exchange partners' expectations can be clearly shown and easily interpreted. Similarly, for institutional pressures, I selected items from the IDC survey mimicking items used in previous research. The interest here is to demonstrate and interpret the distinctive effect of each institutional mechanism. Specifically, I selected a variable on competition (Item 6) to indicate mimetic mechanism, variables on industry standard and association (Items 7 and 8) to indicate normative mechanism, and a variable on laws and regulations (Items 9) to indicate coercive mechanism. And again, I did not merge these items into a higher-level construct. Regarding the level of ERP institutionalization, I found no data that directly measure this construct. Hence I have adopted an approach conventionally used in institutional research – I assessed the institutional effects over time (year after year) and essentially used time as an indirect indicator of institutionalization.

Control Variables. Obviously external factors cannot explain all the variance in IT assimilation across firms. I included the control variables suggested by previous literature as long as I could find the data for these variables. From the IDC survey, I chose three items to represent the responding organization's internal needs for ERP: information integration, workflow coordination, and operation efficiency (Items 10-12). Additionally, I included an item to indicate top management support for ERP use (Item 13). Further, I controlled for the firms' cumulative investment in ERP (Item 14), size of IT staff (Item 15), and the number of years passed since the adoption of ERP (Item 16). I also included each firm's total revenue and number of employees as indicators of firm size. Data for these two variables came from COMPUSTAT. Lastly, I included dummy variables for the firms' industries.

Results

Table 1 shows the means and standard deviations of all variables in all eleven years in this study. The descriptive statistics for the two assimilation measures show that the use of ERP systems was steadily increasing in the sample *Fortune 1000* firms reaching nearly half of the business processes, but most firms used ERP in no more than three functional areas despite the "enterprisewide" idea embedded in the ERP (Davenport 1998). The two areas most frequently reported to use ERP were Finance and Operations.

I also examined 11 correlation tables (one per year, see Appendix B at www.wam.umd.edu/~pwang/ICIS2008.pdf). Kolmogorov-Smirnov and Shapiro-Wilk tests and Q-Q plots indicated that the data were normally distributed. Since I planned to use OLS multiple regression to analyze the data, I calculated power values for each regression model for each year with Cohen's (1988) power table for multiple regression. The power values for the eleven power analyses ranged from .87 to .96, well above the recommended .80 threshold. Also because the data were collected from self-reported surveys, there potentially were common method biases in the data (Podsakoff and Organ 1986). I conducted a Harman's single factor test on all variables. The test results show that ten factors may exist and the factor explaining the most covariance (9.43%) may indicate firm size (because of high loadings on annual revenue and number of employees), not a likely source of common method biases.

	Table 1. Descriptive Statistics																					
		1996		1997		1998		1999		2000		2001		2002		2003		2004		2005		2006	
Assimilation Measures		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
1	Percent of business processes using ERP	5.32	2.62	5.76	4.72	6.19	2.70	10.04	4.11	18.48	11.15	24.60	12.69	31.19	15.75	35.27	16.56	44.22	23.33	48.58	25.36	52.91	27.36
2	Number of functional areas using ERP	1.22	0.48	1.44	0.53	2.21	0.64	2.81	1.28	2.94	1.75	2.77	1.44	2.84	1.83	2.75	1.39	2.96	1.25	2.58	1.53	2.35	1.64
Independent Variables																							
Exchange partners																							
3	Investors	2.26	0.51	3.42	0.49	3.72	0.55	3.60	0.66	3.82	0.49	3.89	0.77	3.65	0.79	3.56	0.48	3.75	0.60	3.42	0.50	3.51	0.58
4	Suppliers	2.74	0.59	3.03	0.65	3.58	0.59	3.71	0.62	3.88	0.55	3.64	0.69	3.49	0.60	3.82	0.73	3.59	0.71	3.69	0.64	3.74	0.52
5	Customers	2.33	0.66	2.89	0.73	3.47	0.76	0.39	0.71	3.58	0.67	3.85	0.55	3.49	0.50	3.56	0.56	3.46	0.62	3.72	0.75	3.48	0.56
Factors in institutional environment																							
6	Competition	2.21	0.65	2.48	0.62	3.69	0.66	3.78	0.80	3.47	0.76	3.75	0.49	3.44	0.57	3.72	0.61	3.92	0.70	3.81	0.59	3.77	0.53
7	Industry standard	2.31	0.49	2.48	0.67	2.85	0.68	3.20	0.73	3.82	0.74	3.85	0.54	3.55	0.62	3.64	0.50	3.74	0.74	3.42	0.63	3.55	0.54
8	Industry association	2.34	0.61	2.32	0.69	2.45	0.54	2.10	0.74	2.58	0.59	2.55	0.51	2.66	0.67	2.75	0.71	3.01	0.50	3.08	0.55	2.97	0.52
9	Laws and regulations	2.19	0.69	2.48	0.56	2.45	0.78	2.88	0.75	2.86	0.62	2.58	0.72	2.67	0.49	2.84	0.59	2.95	0.62	2.90	0.52	2.88	0.62
Control Variables																							
10	Information integration	4.52	0.57	4.43	0.67	4.23	0.76	3.98	0.79	3.75	0.57	3.85	0.58	3.80	0.66	3.89	0.68	3.79	0.57	3.61	0.49	3.56	0.66
11	Workflow coordination	3.94	0.62	3.85	0.52	3.84	0.57	3.57	0.76	3.23	0.72	3.21	0.76	3.32	0.60	3.20	0.69	3.10	0.54	3.13	0.73	3.27	0.66
12	Operation efficiency	4.25	0.64	4.20	0.51	4.17	0.73	4.05	0.76	3.89	0.50	3.87	0.59	3.76	0.53	3.55	0.74	3.59	0.71	3.68	0.68	3.88	0.74
13	Top management support	3.75	0.76	3.85	0.55	3.79	0.79	3.94	0.77	3.88	0.57	3.81	0.57	3.73	0.53	3.90	0.68	3.68	0.67	3.75	0.74	3.71	0.55
14	Cumulative investment in ERP (in millions)	68.38	24.32	83.13	15.30	94.83	16.89	134.40	18.29	158.81	25.48	169.33	29.84	194.98	38.42	204.38	44.30	221.80	49.32	225.64	50.42	239.22	55.49
15	Number of full-time IT employees (in thousands)	13.24	5.83	12.23	6.48	11.93	4.83	12.84	5.94	10.87	4.85	11.34	4.69	9.38	3.88	10.97	4.96	12.48	7.22	13.23	8.30	12.75	7.41
16	Number of years passed since adopting ERP	0.58	0.21	1.30	0.43	2.32	1.23	3.15	1.83	3.32	1.06	3.25	1.39	3.56	1.20	4.73	1.40	5.22	1.76	5.15	1.32	5.88	2.32
17	Annual revenue (in billions)	5.87	11.50	7.05	10.90	6.92	12.81	7.32	13.41	8.11	16.27	8.99	15.69	8.67	16.34	8.20	17.31	9.80	18.71	10.73	21.57	11.09	23.37
18	Number of full-time employees (in thousands)	23.53	58.11	27.07	61.60	28.42	65.19	34.70	70.57	31.96	64.33	26.63	74.98	29.60	69.17	32.23	70.62	28.78	74.25	32.09	78.22	29.35	77.97
19	Industry																							
	Manufacturing	26%		26%		29%		29%		23%		24%		28%		25%		25%		26%		29%	
	Finance and Insurance	22%		21%		22%		24%		25%		24%		23%		22%		24%		20%		18%	
	Retail	13%		13%		14%		12%		11%		14%		13%		14%		14%		14%		13%	
	Utilities	8%		7%		9%		8%		8%		8%		8%		8%		8%		8%		8%	
	Information	5%		5%		5%		5%		3%		5%		4%		4%		6%		5%		4%	
	Other	26%		28%		21%		21%		30%		25%		24%		27%		23%		28%		27%	
N	Number of responding companies	87		122		159		244		255		267		312		309		298		289		260	

Table 2. Results of Regressions on ERP Assimilation (Aggregated Score)											
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Independent Variables											
Exchange partners											
3 Investors	0.94	0.85*	0.98**	0.85**	0.92*	0.93*	0.75*	0.82*	0.74*	0.91*	0.81*
	(0.78)	(0.50)	(0.41)	(0.32)	(0.49)	(0.48)	(0.38)	(0.43)	(0.39)	(0.53)	(0.45)
4 Suppliers	0.68	0.56	0.47*	0.50*	0.60**	0.44*	0.54**	0.79**	0.39**	0.43*	0.58**
	(0.61)	(0.53)	(0.25)	(0.31)	(0.25)	(0.26)	(0.23)	(0.33)	(0.16)	(0.19)	(0.23)
5 Customers	0.80	0.71	0.93	0.95**	0.72*	0.55**	0.68*	0.64**	0.81**	0.89*	0.76*
	(0.67)	(0.52)	(0.62)	(0.37)	(0.43)	(0.22)	(0.30)	(0.28)	(0.34)	(0.41)	(0.36)
Factors in institutional environment											
6 Competition	0.53	0.54	0.63	0.73	0.79**	0.58*	0.83*	0.77**	0.75**	0.90**	0.64**
	(1.05)	(0.78)	(0.70)	(0.56)	(0.32)	(0.34)	(0.44)	(0.32)	(0.29)	(0.30)	(0.22)
7 Industry standard	0.34	0.32	0.03	0.26	0.48	0.68**	0.59*	0.31*	0.85**	0.82**	0.81***
	(0.42)	(0.26)	(0.02)	(0.17)	(0.37)	(0.25)	(0.33)	(0.15)	(0.35)	(0.29)	(0.25)
8 Industry association	0.77	0.74	0.84	0.66	0.69	0.84*	0.93**	0.76*	0.60**	0.53**	0.80**
	(0.64)	(0.50)	(0.56)	(0.73)	(0.62)	(0.49)	(0.32)	(0.38)	(0.25)	(0.19)	(0.27)
9 Laws and regulations	0.56	0.60	0.69	0.59	0.75	0.57	0.63*	0.52*	0.61*	0.74*	0.71**
	(1.86)	(0.86)	(0.87)	(0.65)	(0.57)	(0.38)	(0.37)	(0.30)	(0.30)	(0.32)	(0.28)
Control Variables											
10 Information integration	0.62**	0.94*	0.77*	0.87	0.82	0.72	0.67	0.63	0.66	0.84	0.85
	(0.25)	(0.43)	(0.34)	(0.96)	(0.68)	(0.60)	(0.56)	(0.49)	(0.73)	(1.05)	(1.22)
11 Workflow coordination	0.25*	0.23**	0.28*	0.32	0.28	0.32	0.52	0.56	0.42	0.64	0.56
	(0.11)	(0.09)	(0.16)	(0.29)	(0.19)	(0.20)	(0.43)	(0.43)	(0.30)	(0.46)	(0.62)
12 Operation efficiency	0.20**	0.25**	0.20*	0.29	0.30	0.32	0.34	0.41	0.25	0.32	0.20
	(0.08)	(0.10)	(0.10)	(0.19)	(0.23)	(0.20)	(0.23)	(0.31)	(0.21)	(0.23)	(0.13)
13 Top management support	0.44**	1.02**	0.28*	0.39**	0.79*	0.30*	0.99*	0.87**	0.43**	0.85*	0.89**
	(0.18)	(0.39)	(0.14)	(0.15)	(0.47)	(0.14)	(0.43)	(0.29)	(0.14)	(0.41)	(0.31)
14 Cumulative investment in ERP (in millions)	2.90	3.50*	2.27	2.40*	1.19**	3.75	2.37	3.07*	2.74*	2.95*	2.83**
	(1.94)	(1.94)	(1.89)	(1.09)	(0.48)	(2.68)	(1.83)	(1.80)	(1.52)	(1.55)	(1.18)
15 Number of full-time IT employees (in thousands)	0.01***	0.01***	0.01**	0.09**	0.01**	0.01**	0.01**	0.00*	0.02*	0.01**	0.01*
	(0.00)	(0.00)	(0.00)	(0.04)	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
16 Number of years passed since adopting ERP	3.57***	3.81***	3.92***	2.77***	2.84**	2.65***	2.01**	1.41**	1.91**	1.54**	1.14*
	(0.79)	(1.12)	(1.12)	(0.81)	(0.95)	(0.83)	(0.67)	(0.54)	(0.71)	(0.51)	(0.52)
17 Annual revenue (in billions)	-0.01	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
	(0.04)	(0.01)	(0.00)	(0.03)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.04)
18 Number of full-time employees (in thousands)	-0.32	-0.36	-0.45	-0.26	-0.43	-0.29	-0.41	-0.34	-0.38	-0.43	-0.50
	(0.29)	(0.40)	(0.38)	(0.18)	(0.31)	(0.23)	(0.26)	(0.26)	(0.25)	(0.41)	(0.56)
R^2	0.33	0.24	0.36	0.42	0.44	0.40	0.39	0.40	0.44	0.47	0.49
N	87	122	159	244	255	267	312	309	298	289	260

*$p<0.05$; ** $p<0.01$; *** $p<0.001$; one-tailed tests. Standard errors are in parentheses.

Table 2 shows the results from eleven regressions, each for a year's data between 1996 and 2006. F-test for every regression model showed an overall significance. For every year's data, I entered the control variables first and then added independent variables, observing a significant increase in the coefficient of determination (R^2). Near the bottom of Table 2, the coefficients of determination for the full models show that the variables included in the models explained 24% – 49% of the variation in ERP assimilation. Regarding the significance of parameters related to the exchange partners, all three parameters (investors, suppliers, customers) were significant in and after 1999. Between 1997 and 1999, the three factors' association with ERP assimilation turned significant one after another (investors' was the first, followed by suppliers' and then customers'). Regarding the parameters related to the institutional environment, all were significant in and after 2002. Between 2000 and 2002, there seemed to be a similar spread of significance from the competition factor to other institutional factors. With regard to the significance of internal factors (measured by control variables), the regression results showed that top management support, the size of a firm's IT staff, and the time lapsed since the firm adopted ERP were significantly related to ERP assimilation in all years. In most years, cumulative investment in ERP was also a significant predictor of assimilation. Those internal rationales for ERP, such as information integration, workflow coordination, and operation efficiency, were significantly associated with assimilation in 1996-1998, but not afterwards.

In sum, the positive relationship between institutional pressures and ERP assimilation, as stated in Hypothesis 1, was found in and after 2000 from at least one indicator of such pressures. The positive relationship between exchange partner expectations and ERP assimilation, as stated in Hypothesis 3, was also found in and after 1997 from at least one indicator of such expectations. As ERP progressed toward institutionalization, the effect of all three institutional pressures turned significant. While Hypotheses 2b and 2c, surmising such longitudinal coercive and normative effects, were supported, Hypothesis 2a, suggesting declining mimetic effects on assimilation, was not supported.

Discussion

Implications to Theories on IT Assimilation

Although classic articulations of institutional theory did not limit its scope to a particular level of analysis (Tolbert and Zucker 1996; Zucker 1977), subsequent institutional research has primarily focused on the supra-organizational level (e.g., field- or population-level) analysis or investigation of organizational-level parameters or processes directly interfacing field dynamics such as innovation adoption. The explanatory logic underlying the now well-known argument that early adoptions are based on local calculations of organizations' internal needs and late adoptions just conform to external, institutionalized pressures seems to apply *also* to post-adoptive activities such as assimilation. As I have found in this study, when ERP was at low levels of institutionalization (before 1999), the use of the technology was largely an internal affair motivated by internal needs. After 1999, however, ERP was gradually achieving higher levels of institutionalization, and hence the assimilation decisions and actions became increasingly linked to external pressures from firms' exchange partners and the broader institutional environment. This finding implies that institutional processes function not only at the supra-organizational levels (e.g., organizational field or population), but also within organizations in myriads of processes and projects, wherever an IT is actually used. Hence, the applicability of institutional theory should be extended from field- to organization-level analysis, and at the organizational level, from studying adoption and implementation to examining assimilation.

Unlike those who argue institutional compliance is decoupled from organizational internal dynamics (Meyer and Rowan 1977), I contend that institutionally-based adoption and institutionally-based assimilation are closely linked, both belonging to an organization's innovation journey. I have found evidence that previously well-researched institutional factors such as standards and industry associations shaping IT adoption are also significantly connected to IT assimilation, especially when the IT is highly institutionalized. This result implies that the institutionalization of an IT innovation is a multi-level process that takes place across organizations in a field, at the interfaces of organizations, and within organizations. Accordingly, where assimilation in use is sometimes referred to as "secondary adoption" (Gallivan 2001), I point out that external pressures for the "primary adoption" (at the firm-level) may persist to press for such "secondary adoption" in use by users. The fundamental reason is that institutionalization is a process of collectively developing a cultural understanding shared by those involved in adoption as well as those involved in assimilation that certain IT innovations are beneficial. So the idea that

institutionalization is a social construction of shared cultural understandings is the essence and distinctive feature of institutional theory (Tolbert and Zucker 1996).

This insight I have gained from studying IT assimilation may help resolve the long-time confounding of institutional theory and resource dependence theory. Because institutional compliance is often explained by resource dependence, some have argued that the two theories are converging (Pfeffer and Salancik 2003; Scott 2001). Seeking theoretical synthesis, rather than convergence, Tolbert's (1985) creatively designed study demonstrated that resource dependency is itself subject to institutionalization: that is, when a dependency relationship is not yet institutionalized (e.g., public funding for private universities), organizational choices overrule institutional compliance. Tolbert seemed to assume that when a dependency relationship is institutionalized, institutional compliance would always occur. This assumption may not be always realistic. In fact, most of the resource dependence relationships that firms have are institutionalized (e.g., long-term supplier agreement and the financial market well established for financing and investing), but firms do not necessarily comply with the expectations of these exchange partners all the time. As seen in the results of this study, in 1996, none of pressures from firms' exchange partners had significant association with ERP assimilation. While these firms' relationships with investors, suppliers, and customers were institutionalized, there was no shared understanding among these actors about ERP and thus the institutionalization of ERP was still in-progress in the minds of the exchange partners. Once they have collectively developed a shared understanding of ERP's usefulness in later years, we see significant evidence for institutional compliance – firms comply with the pressures from investors, suppliers, and customers to make full use of ERP. This finding indicates that institutionalized dependency relationship is a necessary but insufficient condition for assimilation derived from institutional compliance. An additional necessary condition is the institutionalization of the IT innovation in the belief systems of exchange partners, i.e., when these actors reach a shared cultural understanding in favor of the innovation for adoption and use. The data also show that different types of exchange partners developed such understanding at different speeds. Table 2 shows that the effect of investors' expectations on assimilation turned significant sooner (in 1997) than the effect of suppliers' or customers' expectations. This difference may indicate that institutionalization in different social groups may have different dynamics and certain social groups may lead or follow others in making sense of IT innovations (Wang and Ramiller 2004).

In sum, both resource dependence theory and institutional theory apply to our understanding of IT assimilation. Each theory offers a distinctive explanation for a necessary but insufficient condition for assimilation induced by external pressures. RDT suggests that firms comply with the expectations of their institutionalized exchange partners (i.e., *whom to listen to*). Institutional theory suggests that firms comply with the institutionalized expectations of their exchange partners (i.e., *what to hear*). Taken together, it was the institutionalized belief of the institutionalized exchange partners that pressed the firms in this sample to assimilate ERP.

Implications to Empirical Research on IT Assimilation

The evidence of external factors affecting IT assimilation found here provides strong support for the empirical research strategy to include both the external and internal factors in the analysis. While assimilation is the process for an organization to *internalize* an IT innovation, it is not an *internal* process. Various external pressures push organizations to comply with their expectations. This study differentiated between the pressures from firms' exchange partners and those from firms' institutional environment, so that I could delineate the applicability of related theories. I further differentiated among the exact sources of external pressures. This practice not only helps detect the differentiated speed at which institutionalization progresses in different social groups, but also aims to help practitioners prioritize their external messages, addressing the challenge of when to listen to whom. Because institutionalization of an IT innovation often takes years, studying assimilation needs to capture the longitudinal effect. Longitudinal studies may add useful perspectives to the insights gained from cross-sectional analysis. For instance, this study confirmed Liang et al.'s (2007) suspicion that the significant institutional effect they found was due to the high-level of institutionalization of ERP. In short, I suggest that assimilation studies consider both the internal and external factors, differentiate the factors with distinctive measures, and do so longitudinally.

Limitations

The findings discussed above should be interpreted within the limitations of this study. First, the secondary nature of this dataset did not allow me to include all known factors for IT assimilation. For example, as previously reviewed, the compatibility of innovation with organization would be a factor to include the analysis. Nonetheless, I would

expect compatibility to interact more with a firm's internal factors than with external factors. Also, besides the responses from the firms' COOs, I did not have data on the assimilation assessment by other organizational members such as end users or IT staff, though I found no indication of common method biases in the data. Additionally, different exchange partners may exert differentiated influences on assimilation, depending on factors such as the partners' power and the importance of the resources to the firm. Although I don't have data on these moderating factors, including them in the regression models would help differentiate the influences among specific exchange partners and the overall influence would still hold. After all, the benefits from this 11-year dataset are apparent: it is longitudinal, questions were consistent across years; and the sample is diverse and representative. These benefits outweigh the potential flaws associated with the secondary nature of the data. Second, while this study shows *what* external factors affected ERP assimilation and *when* they did so, the research design did not allow me to show *how* external factors play their roles in assimilation. To answer the how question, continued ethnographic research on IT assimilation is needed to describe the process external expectations are translated into internal motivations and actions (Yamauchi and Swanson 2007). Third, the dependent variable, assimilation in terms of ERP use in business processes and functions, should not be conflated with the consequences of assimilation in terms of its benefits (Gattiker and Goodhue 2005). Future research with pertinent data should explore whether externally induced assimilation leads to less or more benefits for the organizations. Lastly, only one IT innovation (ERP) was studied here as an example, notwithstanding the study's 11-year examination window. The generalizability of the findings will ultimately rely on studies of more innovations in different periods.

Conclusion: Mindfulness Revisited

The relationship between organizations and their operating environment is an enduring theme in IT innovation research. Thus far, scholars have understood IT adoption and implementation as the outcomes of complex interactions among forces inside and outside the organizations. The emerging research on IT assimilation, though, has paid primary attention to organizations' internal dynamics, as if external forces disappeared as soon as the technology had been set up for use. Liang et al. (2007) recently suggested that the influence of external pressures for innovation persists after implementation, in the decisions made and actions taken to assimilate the innovation in organizational routines. Advancing this important perspective, this longitudinal study has shown that the significance of such persistent external influence on ERP assimilation varies depending on the extent to which ERP is institutionalized.

Practically speaking, from a strategic management perspective, I argue that it is a strategic decision whether, when, and to what extent organizations should assimilate the IT innovations they have adopted. To help firms make this important decision, I suggest a "contingency stakeholder approach." Specifically, since this study has found the level of institutionalization as an important contingency, firms should actively monitor institutionalization in their environment, including the institutionalization of their key resource dependence relationships and the institutionalization of the IT innovations among their exchange partners and other stakeholders in the environment. With regard to the decision to assimilate Second Life mentioned at the outset, it is advisable to recognize the sources of the expectations to assimilate the innovation, assess the firm's relationship with those sources, and detect the extent to which the expectations represent legitimated rationales. In the scenario where firms have already decided to undertake assimilation, I join Liang et al. (2007) to suggest firms to take advantage of various external catalysts for assimilation (e.g., participation in trade, professional, and industry events or organizations). So firms assimilating the RFID technology right now should take opportunities to reach out. This "contingency stakeholder approach" should not be labeled as *mindless* though (Swanson and Ramiller 2004). To the contrary, my approach usefully extends Swanson and Ramiller's (2004) definition for *mindfulness*, which emphasizes reasoning grounded in the organization's "own facts and specifics." In today's world of organizations increasingly open to external forces and processes, any organization's own facts and specifics must include contextualized interpretation of what is going on outside. Mindful innovators monitor, interpret, and prioritize external dynamics when they assimilate new IT.

Acknowledgements

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