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IMPLEMENTATION KNOWLEDGE AND THE ASSIMILATION OF ENTERPRISE INFORMATION SYSTEMS: AN EMPIRICAL STUDY

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1 IMPLEMENTATION KNOWLEDGE AND THE ASSIMILATION OF ENTERPRISE INFORMATION
2 SYSTEMS: AN EMPIRICAL STUDY

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2 **IMPLEMENTATION KNOWLEDGE AND THE ASSIMILATION OF ENTERPRISE INFORMATION**
3 **SYSTEMS: AN EMPIRICAL STUDY**

4 **Abstract**

5 Based on the organizational learning perspective, we present an empirical model to explain the
6 assimilation of complex enterprise systems. We conceptualize systems implementation capability of
7 organizations in terms of two types of knowledge – artifactual knowledge and inter-unit coordination
8 knowledge. We propose that these knowledge dimensions are directly related to the degree of assimilation
9 of enterprise systems. Further, considering that assimilation of IT innovations is steeped in the institutional
10 environment, we also consider the moderating effects of mimetic and normative institutional pressures on
11 the relationship between implementation knowledge and the degree of assimilation.

12 Analysis of survey responses from ERP implementations in seventy-seven organizations reveals
13 support for our main hypotheses that both the implementation knowledge dimensions directly affect
14 assimilation. We also confirm that while mimetic institutional pressures positively moderate the impact of
15 ERP-specific artifactual knowledge on assimilation, normative influences positively moderate the effect of
16 ERP-specific coordination knowledge on assimilation. However, surprisingly mimetic pressures negatively
17 moderate the impact of ERP-specific coordination knowledge on assimilation. The negative moderation
18 suggests that organizations with greater interunit coordination knowledge are more ‘mindful’ towards ERP
19 assimilation and therefore mimetic pressures play a lesser role in affecting assimilation levels. Our findings
20 offer interesting implications for theory and practice.

21 **Keywords**²: IT diffusion and adoption, IT knowledge Capability, Enterprise systems, Institutional aspects of
22 Information Systems, Systems implementation, Questionnaire surveys

² Please note that this paper uses the same dataset as a prior paper (co-authored by us and cited in this manuscript) which appeared in MIS Quarterly (March 2007). It focuses on the effect of institutional forces on the degree of ERP assimilation.

1 1. INTRODUCTION

2 It is widely noted in the industry and the academic literature that the assimilation of new information
3 technology, particularly large scale enterprise systems, into business operations is a highly complex
4 phenomenon. The purchase and adoption of such systems is only the beginning of an extended effort to
5 derive the potential benefits of enterprise systems (Markus et al. 2000). In prior literature we note studies
6 that identify a variety of critical success factors as well as other studies that examine a focused set of
7 factors and thus contribute to a deeper theoretical understanding. As a result, diverse theoretical
8 arguments have been proposed that identify different organizational factors and capabilities as leading to
9 better assimilation of enterprise systems (Fichman 2000; Purvis et al. 2001).

10 This study furthers our main objective of understanding how organization learning capabilities
11 cause assimilation of enterprise systems within organizations. Many notable studies emphasize the
12 importance of firms' learning capabilities (Attewell 1992; Cooper et al. 1990) and consequently learning-
13 related constructs continue to figure prominently in IT assimilation models (Armstrong et al. 1999;
14 Boudreau et al. 2001; Fichman et al. 1997; Teo et al. 2003a). However, we argue that organizational
15 learning of enterprise systems does not occur in isolation from the external environment. Any firm, as also
16 their IT departments, is typically steeped in an institutional context which shapes a firm's response in
17 various ways, to external stimuli such as the introduction of a large-scale innovations (e.g., ERP systems).

18 The focus on such external institutional pressures is recent in literature and stems from the fact
19 that enterprise systems such as ERP, SCM or CRM are complex innovations that present organizations
20 with significant uncertainties about their eventual impact on organizational performance (Markus et al.
21 2000). In fact, the practitioner and academic literature has so extensively described the dire consequences
22 of failed implementations and related-uncertainties that it justifies the basic premise in recent theorizing that
23 organizations are significantly acquiescent towards institutional pressures during assimilation of enterprise

1 systems(Gosain 2004a; Liang et al. 2007; Swanson 1997b). For example, Gosain (2004b) explains how
2 and why institutional forces are active even during the post-adoption stages of ERP systems.

3 In this research therefore we develop the organizational learning perspective to study assimilation
4 and in the process we also reconcile this perspective with the role of institutional forces that appear to be
5 significant during this stage. Using an integrated theoretical lens will help us achieve an enriched
6 understanding of the interaction between firms' IT-innovation-related learning capabilities and their
7 institutional environment. Our approach also follows a recent call in organizational literature to achieve a
8 synthesis between the emergent effect of organization-specific learning with the deterministic effects of
9 institutions on innovation diffusion (Van de Ven et al. 2004). Therefore, our research questions are: *In the*
10 *post-implementation stage how do the learning capabilities of an organization affect the degree of*
11 *assimilation of ERP systems? How do the external institutional pressures moderate the role of the learning*
12 *capabilities on the ERP assimilation?*

13 There are two premises this study is based on. First, organizations face various learning
14 challenges not only during the implementation phase but also post-implementation, such as
15 comprehending the features of the new system, understanding the cross-unit interdependencies imposed
16 by the enterprise systems, and finally aligning the work practices and technical features suitably
17 (Baskerville et al. 2001). Second, the uncertainties characterizing selection and adoption of enterprise
18 systems continue to persist beyond the implementation phase. These uncertainties, for example, manifest
19 in the indecisions of users facing the choice of retaining legacy or shadow systems (Robey et al. 2002) and
20 devising workarounds to the new ERP system (Boudreau et al. 2005).

21 Combining the institutional perspective with the learning perspective provides us with an
22 opportunity to shed more light on the innovation assimilation processes because the evidence on how
23 learning capabilities affect assimilation is ambiguous. For example, Armstrong and Sambamurthy (1999)
24 find partial support for the knowledge-related construct during IT assimilation. A study of the post-

1 implementation ERP context reveals that situated learning is more useful than formal training (Boudreau et
2 al. 2001). In a study of financial EDI, absorptive capacity, a construct that signifies an organization's ability
3 to apply an innovation towards improving performance, is found to indirectly affect adoption of EDI
4 technology, but its direct effect on adoption is not supported (Teo et al. 2003a). Another recent study further
5 finds that legitimacy factors are important for participation in B2B marketplaces but not for usage (Son et al.
6 2004). Therefore, we believe that a deeper understanding of the role of IT-innovation-related learning can
7 be gained by studying its interaction with institutional forces.

8 This paper is structured as follows. In the following section we clarify the notion of assimilation
9 during the post-implementation stage in the context of ERP systems. Then in section 3 we develop the
10 hypotheses and present the research model. Section 4 presents the survey instrument development, data
11 collection and results. Limitations and implications of this study are discussed in section 5.

12 2. LEARNING CHALLENGES FACING ERP IMPLEMENTATION

13 The innovation assimilation literature has used the term "assimilation" quite liberally. Considering
14 that the assimilation of enterprise systems can be spread over a long time period, studies in this context
15 have been strongly guided by Kwon and Zmud's (1987) stage model of innovation-diffusion. As per the
16 stage model, the innovation assimilation process within an organization stretches from initial awareness of
17 the innovation to its formal adoption and full-scale infusion. Further, the set of factors that lead to adoption
18 of IT innovations is not necessarily the same as that which facilitates assimilation in the latter stages
19 (Cooper et al. 1990). This observation is consistent with recent studies which present similar findings in the
20 context of ERP implementations (Somers et al. 2001). Thus, organizations may readily adopt the ERP
21 technology, but the speed and success of the actual infusion and routinization of the ERP may vary
22 depending on other factors such as, for example, compatible business processes and practices. This delay
23 between adoption (purchase) and full deployment is called an *assimilation gap* (Fichman et al. 1999).
24 Studies of why assimilation gaps differ across organizations point to the difference in post adoption-

1 behaviors and related characteristics between organizations (Fichman et al. 1999). Our focus is on the
2 'shakedown' and 'onward and upward' phases (using the terminology of Markus and Tanis (Markus et al.
3 2000)). Thus, we adopt the definition by Purvis et al. (2001) as "the extent to which the use of technology
4 diffuses across the organizational projects or work processes and becomes routinized in the activities of
5 those projects and processes."

6 In developing the learning perspective of innovation assimilation, Attewell (1992) asserts that the
7 knowledge required by organizations to use complex technologies is difficult to transfer and thus is
8 acquired slowly as against other simpler technologies. A multitude of learning challenges arise in the
9 assimilation phase as the system is rolled out to the end-users, which include the operational level
10 personnel as well as middle-level managers. *First*, since an ERP system is at its core a transaction
11 processing system that underlies the internal supply chain of organizations from purchasing to sales and
12 even post-sales, it creates significant business process interdependencies (Gattiker et al. 2005). By virtue
13 of the common data and process models underlying the ERP system, the business-level data which maybe
14 captured at one point in the supply chain is often used at multiple other points. This requires most users to
15 understand the consequences of their actions on the workflow in other inter-dependent units. For example,
16 Baskerville et al. (2001) describe how the users of enterprise system could adapt to a new ERP system
17 only when they were able to expand their business knowledge about other functional domains. The users,
18 for example, must comprehend how their system modules triggers tasks in other parts of the organizations,
19 how the data input in one functional unit affects decisions and actions in other units or how the quality of
20 data entered at one location affects decisions in other organizational units (Jones et al. 2004; Robey et al.
21 2002). Knowing these interdependencies leads to better understanding of the importance of fully using the
22 system features. Without such knowledge the users are limited in solving coordination problems (Kim et al.
23 2005) and thus are more likely, for instance, to resort to inventing workarounds or retaining legacy systems
24 in parallel. Comprehension of such cross-unit interdependencies is itself facilitated by the interactions

1 routines between individuals and subunits regarding usage of the system (Gosain 2005). The *knowledge as*
2 *a network view* (Kogut 2000) proposes that knowledge of an organization is not static rather it is embedded
3 in the interaction routines between organizational subunits or members. Particularly, in the case of an ERP
4 system it is difficult for the users to be fully aware of how the system will perform when used (Attewell
5 1992). It is only when they have established interaction routines concerning the ERP usage that they begin
6 to comprehend it better.

7 *Second*, assimilating ERP systems also requires that the ERP vendors transfer required
8 knowledge about the new system itself, both tacit and explicit to the user organization (Ko et al. 2005). This
9 knowledge for example, can refer to guidelines for manipulating configuration tables so that they align with
10 the actual business processes. Alternately, it may refer to the business rules that translate a purchase
11 order into the related accounting information. For example, an enterprise system such as SAP has normally
12 25,000 business rules to be encoded by implementation specialists (Lehrer 2005). After implementation it is
13 normal for business users to want to alter or have altered some of these business rules for better alignment
14 with their business processes. This requires a user organization to keep abreast of a considerable amount
15 of tacit and explicit knowledge about the technical features of the system. Vendor conferences and training
16 programs are often hosted in order to train the user on existing or newer versions of such systems (Hirt et
17 al. 2001a). Not only are the IT specialists of the user organizations trained but such training is also
18 imparted to the business users. Many organizations implement a centralized support unit that guides
19 business units and coordinates their adaptations (Park et al. 2005). Thus, an organization assimilating an
20 ERP system has to make a concerted effort to acquire knowledge in multiple ways.

21 3. RESEARCH MODEL

22 3.1 ERP-Specific Learning Capabilities

23 We refer to ERP-specific artifactual knowledge as the knowledge possessed by an implementing
24 firm pertaining to the features of the ERP system. Artifactual knowledge is embedded in the ERP systems

1 as the ERP vendors distill their tacit and explicit knowledge of software and standardized business
2 processes and program it into the application. Another example in a non-IT setting is knowledge conveyed
3 through a patent. Thus, the ERP systems and accompanying documentation contain the 'cognitive residue'
4 (Khine et al. 2006) of the knowledge of the ERP vendors that is then conveyed to the client organization
5 through training session and instituting support services. It is largely the technical specialists who acquire
6 this knowledge from consultants or ERP vendors during implementation. These individuals or teams are
7 then designated as liaisons or also act as expert users (Hirt et al. 2001b). Expert users however are highly
8 conversant only with using the system on a one-on-one basis and need not be fully conversant with the
9 more difficult aspects of facilitating inter-unit dependencies using the software.

10 ERP-specific interunit coordination knowledge refers to the tacit expertise and cognitive
11 understanding collectively possessed by the relevant subunits within an implementing firm with regard to
12 managing the operational interunit dependencies. Rather than being acquired from external parties, this
13 knowledge can only be cultivated internally by managers of various sub-units over an extended period of
14 time (Gosain 2005).

15 Existing studies on IT assimilation have examined learning-based constructs in various ways to
16 account for the difference in knowledge barriers faced by organizations. Examples are managerial IT
17 knowledge (Boynton et al. 1994), objective knowledge about their business (Armstrong et al. 1999), system
18 of knowing (Armstrong et al. 1999) and IT infrastructure sophistication (Teo et al. 2003a). However, the
19 results do not consistently establish that learning positively affects assimilation. For example, existing level
20 of CIO's IT and business knowledge was found to be effective in influencing IT use (Armstrong et al. 1999;
21 Boynton et al. 1994) but senior business executive's 'system of knowing' did not have a significant
22 influence on IT assimilation (Armstrong et al. 1999). Here, 'system of knowing' was operationalized in terms
23 of the interactions between CIO and members of the top management team and is somewhat consistent
24 with our construct of ERP-specific coordination knowledge.

1 Consideration of both dimensions of learning capability is important because a significant number
2 of the firms that suffer from implementation failures are also large firms. Large firms are likely to have
3 sufficient artifactual knowledge such as manpower and technical resources including - access to vendors
4 and high-caliber IT professionals. But their implementation failures suggest that apart from artifactual
5 knowledge, the presence of requisite knowledge-structures (a.k.a ERP-specific coordination knowledge)
6 may also enhance their ability to assimilate enterprise systems. At the organizational and sub-unit level, the
7 structural, cognitive and relational dimensions of inter-unit ties represent the knowledge structures, which
8 enhance the creation of intellectual capital (Nahapiet et al. 1998). These knowledge structures essentially
9 refer to the commonality among sub-units in terms of their understanding of the ERP system, or readiness
10 towards assimilating the new system.

11 We argue that the lack of a sufficient level of ERP-specific artifactual or inter-unit coordination
12 knowledge precludes users' comprehension of the ERP system in terms of the cross-unit
13 interdependencies. Since the ERP system is a complex innovation, its complete assimilation requires users
14 to engage in learning-by-doing. Training sessions generally oriented towards stimulating learning-by-doing
15 therefore serve to enhance an organization's artifactual knowledge. Similarly, lack of who-knows-what
16 knowledge retards problem solving when users encounter bottlenecks during usage of the system. The
17 users' comprehension of cross-unit interdependencies is facilitated when all departments have a common
18 understanding of the broader objectives and implications of system. It encourages cross-unit interactions
19 between individuals regarding adapting the work processes to the new system. A lack of these knowledge
20 types is more likely to lead users to continue maintaining their shadow systems (i.e., legacy systems) which
21 they are very accustomed to (Boudreau et al. 2001). A tendency to devise workarounds, and thus avoid
22 assimilating the ERP completely, is heightened due to the risk-averseness of the users. Risk arises
23 because, irrespective of how the ERP eventually performs, users themselves are accountable for any

1 operational errors in fulfilling customer orders, making inventory decisions, payments, etc. Therefore, we
2 expect:

3 *Hypothesis 1: Higher level of ERP-specific artifactual knowledge will lead to higher level of ERP*
4 *assimilation in the enterprise.*

5 *Hypothesis 2: Higher level of ERP-specific interunit coordination knowledge will lead to higher level of*
6 *ERP assimilation in the enterprise.*

7 **3.2 Moderating Effects of Institutional Forces**

8 The role of external institutional pressures in ERP assimilation processes is closely related to the
9 characteristic of complex innovations such as enterprise systems, in the sense that outcome uncertainties
10 and goal ambiguities arising during its assimilation renders the organization acquiescent to institutional
11 pressures (Gosain 2004b). During the process of ERP assimilation, users need to figure out when to modify
12 existing business processes and when to alter the ERP system. These incremental adjustments to system
13 and processes are equally important and continue after initial implementation (Hirt et al. 2001a; Markus et
14 al. 2000). Further, various business units continually invest in various add-ons (Mabert et al. 2001) which
15 again need to be compatible with the new ERP system. For example, though the bulk of customization of
16 an ERP package is done during the initial implementation (Luo et al. 2004), users need to make
17 incremental changes in order to fully utilize the full potential of the system. As firms continue developing
18 new products, capabilities and altering their business processes, continuous mutual adaptations between
19 enterprise systems and organization users become especially important. However, considering the
20 complexity of the ERP system, it is often difficult for users in various functional units to be certain of having
21 made the right decisions. This dilemma is further compounded by the difficulty of ascertaining the link
22 between the use of ERP and its financial benefits.

23 The existence of two different streams of research on organizational change, one that explains
24 change as resulting from firms' internal learning capabilities (and guided by its strategy to achieve

1 competitive advantage) and another that explains change as resulting from institutional influences, has led
2 scholars to conceptually reconcile the two perspectives (Boyd et al. 2004; Van de Ven et al. 2004). The co-
3 existence highlights the duality between structure and action³. Structural forces by definition affect all
4 organizations equally and therefore are likely to lead to isomorphism whereas internal organizational
5 capabilities are the ones that lead to differential advantage (Van de Ven et al. 2004). This conceptualization
6 is consistent with our primary argument in this paper. In particular, we argue that much of the IT-related
7 adaptations organizations engage in is not only a result of their inherent learning capabilities, but also
8 moderated by the institutional environment. In the case of enterprise systems, organizations have reserves
9 of knowledge about the innovation by virtue of training and the educational background of the personnel.
10 Organizations also develop salient intra-organizational linkages to promote discourse about usage of
11 innovations (Hirt et al. 2001a). Thus, the extent to which they can imitate their successful competitors' ERP
12 practices or adopt the ERP practices of its business partners is a function of their knowledge stock and
13 their capability to cultivate an internal discourse aimed towards assimilating the innovation.

14 Therefore, it is necessary to hypothesize the role of institutional influences and how they moderate
15 the change potentially resulting from a firm's learning capabilities. To study the moderating effects on the
16 link between firm learning capabilities and degree of assimilation, two types of institutional pressures
17 become especially relevant – mimetic and normative. We develop hypotheses next based on these two as
18 moderating constructs.

19 *Mimetic Forces*

20 Mimetic mechanism operates when, under conditions of outcome uncertainty, organizations model
21 themselves after other organizations in their field perceived to be successful (Galaskiewicz et al. 1989).
22 Besides, conferring legitimacy which is a key imperative for organizational actors, imitation also helps them

³ Structure and action are described in the institutional theory context. Structure refers to the structure of institutional environment rather than organizational structure. Action refers to the idiosyncratic behavior of organizations.

1 economize on search costs, and reduce the uncertainty related to the outcomes of their decisions. By
2 nature, imitation has been found to occur between role-equivalent organizations, i.e., competitors or firms
3 competing for similar resources (Burt 1987). A competitor being successful suggests to the observers that
4 one of the factors that contributed to its success could have been the innovation under consideration
5 (Strang et al. 2001). For example, a successful competitor adopting that vendor's product is a signal to the
6 ERP adopter to assimilate the new system as fully as possible (Liang et al. 2007)⁴.

7 While mimetic influences may directly influence organizations to adopt popular products (Teo et al.
8 2003b), we argue that its impact during post-implementation is not necessarily as direct. In this stage,
9 *learning-by-using* and *learning-by-doing* become the paradigms under which organizations transition from
10 receiving support from consultants and vendors to self-support and self-service (Attewell 1992). This
11 "reinvention" of the ERP system occurs within a focal organization as it directs its learning efforts towards
12 mimicking the assimilation levels of competitors (and other "structurally equivalent" organizations). In other
13 words, while an organization may be able to better assimilate ERP systems by virtue of its learning
14 capabilities, mimetic influences provide further motivation to exploit such capabilities more fully. Therefore,
15 we propose that

16 *Hypothesis 3: Mimetic influences positively moderate the effect of ERP-specific artifactual knowledge on*
17 *the degree of ERP assimilation in post-implementation phases.*

18 *Hypothesis 4: Mimetic influences positively moderate the effect of ERP-specific interunit coordination*
19 *knowledge on the degree of ERP assimilation in post-implementation phases.*

20 ***Normative Forces***

21 Normative influences arise from the professionalization of organizational actors in the extended
22 network of organizations. These networks (or 'organizational fields', the term coined by DiMaggio and
23 Powell (1983)) differ depending on the type of industry. In industries where training and formal education

⁴ See this paper for a review of empirical IS literature examining mimetic behaviors of firms.

1 are highly important, the normative influences manifest when personnel embedded in their professional
2 networks transmit norms to peers across organizations. For other industries, the organizational fields may
3 consist of suppliers, customers and other partner enterprises. These influences are different from the
4 mimetic influences in that these are considered to result from *agreement* among the members of the
5 organizational fields, i.e., these influences have more rational bases than mimetic influences.

6 A consequence of the uncertainty regarding the degree of adaptation during ERP assimilation is
7 that users tend to rely more on the professional norms that propagate throughout the community network of
8 suppliers and customers (Swanson 1997a). These are external entities in the highest proximity to the users
9 in the post-implementation stage. In this type of environment, the 'organizing vision' (Swanson 1997)
10 becomes a significant force that shapes individual beliefs, attitudes, and ultimately behavior. We argue that
11 norms accepted in the subset of external entities - suppliers, customers and partners - of the industry-wide
12 community, have a significant influence on the assimilation of the ERP system within the organization.
13 These norms guide the users about the extent to which they should adapt their work routines to the ERP
14 package and conversely what features of the ERP package can be modified to suit their needs.

15 In the ERP context, such norms signify the likely technological trajectory of the majority of the user
16 organizations and therefore are believed to be important to adhere to. This is because it is uncertain at
17 what point in time, the business activities of suppliers, customers and other partners become
18 interdependent (Swanson 1997a), at which time effecting change quickly to be compliant with the norms,
19 may be costly. In the absence of norms or if the norms are weak, then the uncertainty faced by users and
20 managers of the ERP systems will be higher rendering them directionless to a certain extent, in terms of
21 specific adaptations.

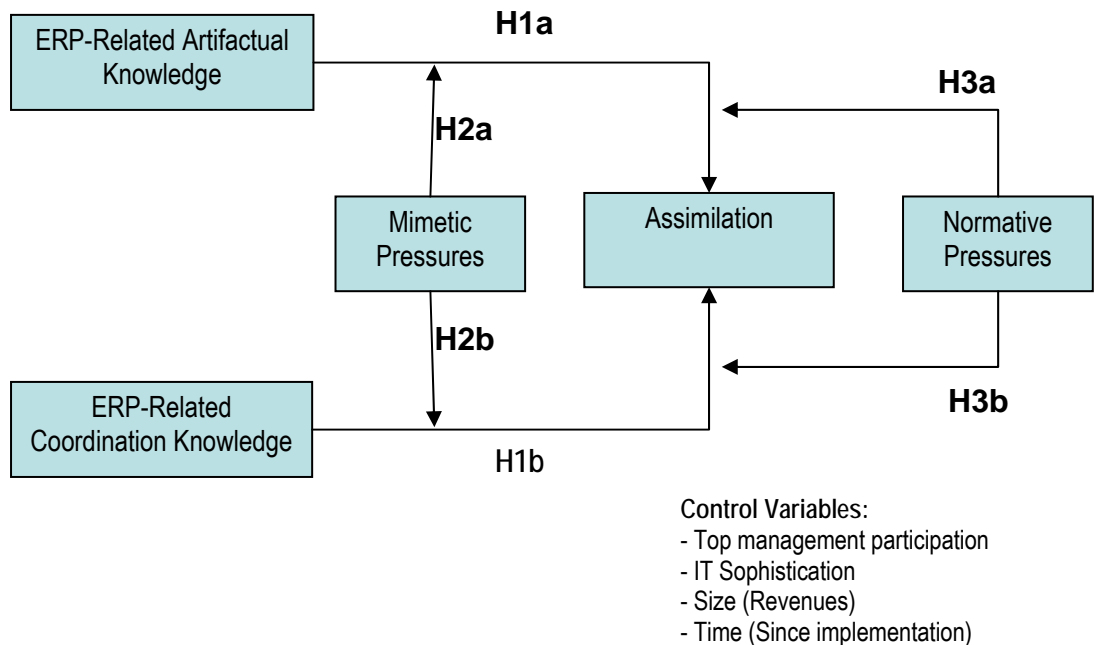
22 We argue that in the case of complex innovations, the learning capabilities of organizations helps
23 them to sift, filter and absorb the extensive amount of information about using the ERP system that is
24 acquired from the members of organizational fields. In other words, the ERP-related artifactual and

1 coordination knowledge allows organizations to implement the normative understandings about ERP
2 systems which results in higher levels of assimilation.

3 *Hypothesis 5: Normative influences positively moderates the effect of ERP-specific artifactual knowledge*
4 *on the degree of ERP assimilation in post-implementation phases.*

5 *Hypothesis 6: Normative influences positively moderates the effect of ERP-specific interunit coordination*
6 *knowledge on the degree of ERP assimilation in post-implementation phases.*

7 Figure 1 depicts our research model. In addition to our main constructs, we also included control
8 variables such as the top management participation, time since implementation of the ERP, the size of the
9 firm (in terms of revenue) and the IT sophistication of the respondent firm prior to the ERP implementation.
10 The last control variable is included to control for the variation across the sample of firms in terms of their
11 overall level of IT-sophistication.



12

13

Figure 1: Research Model

14 4. RESEARCH METHOD AND DATA

15 4.1 Instrument Development

1 In order to develop an instrument for testing and validating the proposed technology innovation
2 assimilation model and its hypotheses, we first conducted a literature review to identify measurement items
3 for the proposed constructs in our research model. The sources of the measurement items are summarized
4 in Table 2⁵. Some modifications were made to make the scales more suitable in the context of ERP
5 assimilation. Since the intended target organizations are the companies that have implemented ERP
6 systems in China, the questionnaire items were translated into Chinese and a panel consisting of experts in
7 the Chinese ERP industry examined the face validity of the items. A few changes to the scales were made
8 in order to match the Chinese context.

9 All of the extraneous constructs in the model are operationalized (except ERP assimilation) as
10 reflective constructs. All of the items of reflective constructs were evaluated on a 5-point Likert scale on
11 which 1 means “strongly disagree” (or “very low”) and 5 means “strongly agree” (or “very high”). The
12 dependent construct, ERP assimilation, was operationalized as a formative construct as discussed next.

13 **Assimilation.** The four dimensions of EDI usage as identified by Massetti and Zmud (1996) were used
14 as a guide to construct a three-item formative scale. However, the scale items could not be replicated
15 because of the differing contexts of ERP vs. EDI. Whereas in an EDI context, usage *volume* can be
16 measured by specifying the particular types of transactions with suppliers/customers conducted using the
17 EDI, the same scheme could not be used for the ERP system because different respondents had
18 implemented a different set of modules. In the interest of maintaining the conciseness of the questionnaire
19 (and thus the response rate), the volume dimension was measured by asking respondents to indicate the
20 percentage of business processes that were conducted using the ERP out of all business processes.
21 *Diversity* represents the number of a firm’s business functional areas automated by ERP technology. *Depth*
22 was measured by asking the respondents to indicate the vertical impact of the ERP system on their
23 organization activities— ranging from just planning to decision-making. In this research setting, ERP is

⁵ The appendix presents the scale items from Liang et al. (2007).

1 intended for back office automation rather than linking electronically with trading partners, so we did not
2 include the breadth dimension in the scale for the degree of ERP assimilation.

3 **Learning Capabilities:** It is well-recognized that scales for knowledge-related constructs need to be
4 devised specific to the context. Existing literature provided a rich basis on which we created the scales
5 anew for both ERP-related learning dimensions (Table 1)⁶. To capture artifactual knowledge, we developed
6 items that represent typical modes of transfer of such knowledge such as training and support services
7 which always pertain to the knowledge about the ERP systems that is transferred from the ERP vendors or
8 implementation consultants. For example, power users and IT staff are an important feature of every staff
9 and operations department (Attewell 1992) and office workers and managers alike depend upon such
10 people for finding solutions to new system-related problems, a facet captured in our scale. Similarly, in the
11 post-implementation stages of ERP systems most of the know-how of the new system has been transferred
12 from the vendors and consultants to the users who are now expected to be in the self-service mode
13 (Attewell 1992). Therefore, it is essential to capture the extent of ERP-related knowledge transferred from
14 the consultants and vendors to the organizational users. We measured artifactual knowledge using a five-
15 item reflective scale and these refer to the ERP-related training provided to the users, the general level of
16 technical support that the organization can provide its users, and the degree of knowledge acquired from
17 the ERP vendor. The choice of these items is consistent with the knowledge-as-stock notion and aptly
18 captures the knowledge stock about the new ERP system possessed by the firm. To measure ERP-related
19 interunit coordination knowledge, we focus on inter-departmental interactions regarding ERP usage and
20 their common understanding of the artifact. This is because in the ERP context the inter-departmental
21 coordination is an indicator of the organization's capability to effectively utilize this understanding to solve
22 the managerial problems such as those about jurisdiction and ownership of the data and processes

⁶ As we shall discuss later, during exploratory factor analysis we found this construct to have two dimensions. ERP artifactual knowledge was therefore represented in our data analysis as a second order construct with two first-order factors.

1 embedded in the ERP system. Similarly, other problems pertain to the responsibility for operational delays
 2 and inefficiencies which may arise if the ERP system did not function as intended. In these cases,
 3 interdepartmental conflict is more likely to arise and the assimilation of the ERP system likely to be
 4 retarded. A three-item reflective scale was used.

5 **Table 1: Learning Capability Sub-Constructs**

Artifactual Knowledge	Support	<ol style="list-style-type: none"> 1. It is well known who can help solve problems associated with the ERP package. 2. Our company can provide adequate technical support for using ERP. 3. Our company obtained enough knowledge about using ERP from the ERP vendor.
	Training	<ol style="list-style-type: none"> 1. Our company provided ERP training opportunities to employees on a regular basis. 2. The IT department provided specific information for using different ERP modules.
Coordination Knowledge		<ol style="list-style-type: none"> 1. All departments in our company were able to use a common language to talk about ERP usage. 2. All departments in our company had a clear understanding about the goal of using the ERP system. 3. Our company had the ability to manage interdepartmental issues relating to ERP usage.

6

7 **Mimetic Pressures.** Following Teo et al. (2003b), this construct was measured in terms of the
 8 perceived extent to which competitors have benefited by *adopting* ERP⁷. In our context, we believed that
 9 the respondents might not be able to accurately gauge the extent to which their competitors have
 10 *assimilated* ERP (beginning from the adoption stage to the infusion stage), however they would be
 11 knowledgeable about their competitors' adoption decisions and the degree of success in the subsequent
 12 use. We adapted Teo et al.'s (2003b) scale in the following way. Instead of capturing two dimensions of this
 13 construct in the context of EDI – extent of adoption of among competitors and perceived success of
 14 adopters who are competitors, we only measured the latter dimension (i.e., *perceived success* of adopters

⁷ It was necessary to refer to ERP adoption by competitors, and not to its *assimilation*, because the respondents could not possibly be knowledgeable about the extent of ERP assimilation.

1 who were competitors) because the first dimension (competitors' *adoption decisions*) is more likely to affect
2 adoption but less likely to affect post-implementation usage.

3 Normative Pressures. This refers to the perceived extent to which members of the dyadic relational
4 channels have adopted ERP and the extent to which the government and industry agencies promote the
5 use of information technology and especially the ERP systems. This is consistent with the three dimensions
6 of Teo et al. (2003b) measure except we did not create three separate sub-constructs but instead used a
7 three-item reflective scale.

8 *Top management participation* was adapted as is from Chatterjee et al. (2002) as a three-item
9 reflective scale. It refers to the extent to which top management actively participates in the management of
10 the ERP initiative. Thus, respondents were asked to rate, on a 1-5 Likert scale, the extent to which top
11 management articulated a vision for the organizational use of the ERP, formulated a strategy and
12 established goals and standards to monitor the ERP project.

13 4.2 Data Collection

14 We used a field survey method for this study to tap responses from managers of Chinese
15 companies that have implemented ERP systems. A sample was drawn from the clients of UFIDA, a leading
16 ERP vendor which has the largest market share in China's ERP market. We requested a senior marketing
17 manager at UFIDA to randomly distribute 100 questionnaires to the directors of UFIDA's 14 subsidiaries
18 and 15 offices. These subsidiaries and offices are located in China's four self-governing cities, three
19 autonomous regions, and 17 provinces, representing a wide range of geographical and cultural diversity.
20 Each of the 29 directors randomly selected some ERP customers from his or her region and handed
21 questionnaires to the persons who supervised the ERP projects in these companies. This design is suitable
22 for this research in light of our observation of China's unique social and cultural context. In China, many
23 business transactions are largely based on personal relationships instead of formal rules (Martinsons et al.
24 1997). Collecting data for research purposes from Chinese companies is extremely difficult unless it is done

1 through personal liaison. Only with the help from UFIDA were we able to access the key person in the ERP
2 project of each company of interest. These key informants were members of the senior management team
3 who played a key role in the ERP initiative within their companies. These respondents not only were
4 involved during ERP vendor selection but also supervised its implementation, and interacted with other
5 members of the top management frequently with respect to ERP issues in the company. Hence, the key
6 informants are likely to provide accurate evaluations of external pressures imposed on their companies,
7 and top management's beliefs and participation regarding ERP usage. Even after the ERP projects were
8 over, the ERP usage status report was a topic of many companies' management meetings and
9 documented. The key informants also have access to this information. In order to preserve relative
10 objectivity of ERP assimilation measures, the key informants were requested to provide answers based on
11 minutes of the meetings or company documentations. An additional aspect of this channel of data collection
12 was that UFIDA's sales representatives had continuous interaction with their clients even after
13 implementations were completed and they intentionally monitored their ERP usage for the purpose of
14 acquiring additional sales and maintenance contracts. This alleviated our concern that the survey
15 responses would be inaccurate because of the memory related issues.

16 The final respondent sample included several finance managers because of the peculiarity of the
17 ERP implementation history in Chinese companies (Table 5). The precedent of ERP software products in
18 China was accounting and financial software. Therefore, a majority of Chinese ERP vendors and their
19 clients were financial software vendors and financial managers respectively (Xue et al. 2005). Further,
20 finance managers also emerged at the helm of many IT initiatives within Chinese companies.

21
22
23
24

Table 3. Types of Participating Firms and Ownership

		N	Percentage (%)
Types of business	Manufacturing	52	67.5
	Service	21	27.3
	Other	4	5.2
Ownership	Private	35	45.5
	Publicly Traded	20	26.0
	Joint venture	14	18.2
	State owned	8	10.4

Table 4. Responding Company Demographics

	Mean	SD
Number of employees	880.62	1777.90
Revenues (million dollars)	48.47	69.12
Time* (months)	21.88	15.47

Time period from the completion of the ERP project to the point when the questionnaire was filled out.

1

2 Of the 100 questionnaires distributed, 80 questionnaires were returned and 77 questionnaires were
 3 completed and usable for data analysis, showing an effective response rate of 77.0%. The respondents
 4 were mostly senior managers or middle level managers in the IT or finance departments. In many Chinese
 5 firms, there is no CIO or CFO position and directors are the top most managerial position that oversees
 6 these functions.

7

Table 5. Respondent Demographics

Title	CEO	VP	CIO	CFO	IT director	Finance director	Finance manager	Sales director	Total
N	2	3	10	8	16	18	16	4	77
%	3	4	13	10	21	23	21	5	100

8

9 **5. RESULTS AND ANALYSES**

10 We used mostly PLS to test our model.

11 **5.1 Measurement Evaluation**

12 All the reliability coefficients are above .70 and each AVE is above .50, indicating that the
 13 measurements are reliable and the latent construct can account for at least 50% of the variance in the
 14 items. Table 6 also shows the factor loadings of the reflective constructs. The loadings are in an acceptable
 15 range and the t-values indicate that they are significant at the .01 level. The square root of the AVE of each

1 construct is greater than all of its correlations with other constructs, supporting sufficient discriminant
2 validity (Chin 1998). As Chin (1998) notes, covariance based estimates such as reliability and AVE are not
3 applicable for evaluating formative constructs. Instead, the path weights of indicators need to be examined
4 to check if they significantly contribute to the emergent construct (please see Tables 6 & 7). Therefore, the
5 measurement of ERP assimilation was assessed by examining significance of the three path weights. All
6 three path weights are significant at the .01 level, suggesting that they contribute significantly from different
7 paths to form the construct of ERP assimilation.

8 During the measurement evaluation process, two changes were made so as to maintain the
9 statistical strength of this study. Our data analysis showed that the five items used to measure ERP
10 artifactual knowledge actually loaded on two separate constructs, rather than a single construct, as we
11 proposed. To accommodate this contingent finding, we took an *ad hoc* approach to modeling this construct
12 as a second-order construct consisting of two first-order constructs. Later in the analysis section, we will
13 justify how it can be viewed to have multiple dimensions which warrants a second order modeling
14 approach.

15 5.2 Common Method Bias

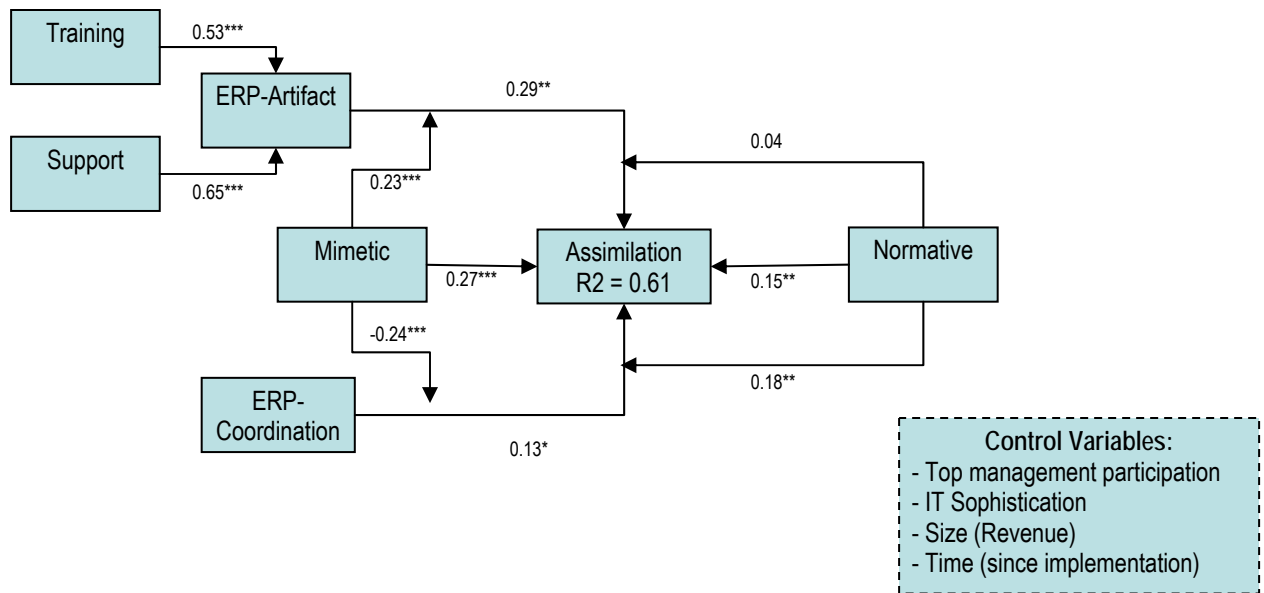
16 As recommended by Podsakoff and Organ (1986), in the questionnaire we asked the respondent
17 not to estimate ERP assimilation outcome measures according to personal experience, but to get this
18 information from minutes of company meetings or documentation. Although this could not be confirmed
19 directly, a Harmon one-factor test (Podsakoff et al. 1986) was conducted on the crucial variables in our
20 theoretical model which are ERP artifactual knowledge, ERP coordination knowledge, mimetic pressures,
21 normative pressures, ERP assimilation and top management participation. Results from this test showed
22 that ten factors are present and the covariance explained range from 7.07% to 13.29%, indicating that
23 common method biases are not a likely contaminant of the results observed in this investigation.

24 5.3 Hypotheses Testing

1 Figure 2 presents the estimates obtained from PLS analysis. Overall, the R^2 value of .61 indicates
2 that the model explains a good amount of variance in ERP assimilation and a substantial increase from the
3 base model (Liang et al. 2007), which achieved an R-square of 0.395. Consistent with our first two
4 hypotheses, we did find significant links between learning capabilities and ERP assimilation. The path
5 between artifactual knowledge and assimilation is significant at the 0.01 level, supporting H1. H2 is partially
6 supported since its p-value is slightly higher but below 0.1.

7 Following Chin et al. (2003), we tested the four hypothesized moderating effects out of which we
8 found support for two. We found that mimetic pressures indeed strengthen the effect of ERP artifactual
9 knowledge on the degree of ERP assimilation ($b = 0.23$, $p < 0.01$). Similarly, normative pressures
10 strengthen the effect of ERP coordination knowledge ($b = 0.18$, $p < 0.05$). However, surprisingly ERP
11 mimetic pressures weaken the effect of coordination knowledge ($b = -0.24$, $p < 0.01$). Finally, the
12 moderating effect of normative pressures on ERP artifactual knowledge \rightarrow Assimilation relationship is not
13 significant. As Chin et al. (2003) suggested, we calculated Cohen's effect size to confirm the overall
14 moderating effects. The Cohen's effect size was 0.34, indicating the existence of strong moderating effects.
15 Following Carte and Russell (2003), we tested whether the variance explained by the moderation effects is
16 significant beyond the main effects by calculating the F-statistic from the incremental R-squares of the
17 models with moderating effects. Four models were run including only each of the hypothesized moderating
18 in turn and excluding the rest. Then an F-statistic was computed by comparing the R-squares with a base
19 model that included only the main effects. The F-statistic for the model including only the moderating effect
20 ERP-Artifact X NORMATIVE was not significant at 0.05 level, but the rest of the moderating effects are all
21 significant at the 0.05 level, thus consistent with the significance of the path coefficients above. A fifth
22 model was run by including all moderating effects. The F-statistic for this model is 5.71 and thus significant
23 at the 0.001 level. In addition, a power analysis was performed to demonstrate that the moderation tests
24 have adequate power. Following (Cohen 1988), we find that the power value at 0.05 level for our

1 moderation tests is above 0.90, suggesting that the moderation effects are unlikely to be biased by Type II
 2 errors.



3
 4 *** p < 0.01, ** p < 0.05, * p < 0.1
 5

Figure 2. PLS Results

6 5.4 Discussion and Limitations

7 The results provide strong support for our main effects and also for two of the moderating effects
 8 hypothesized. We found that overall learning capabilities are indeed a significant predictor of the degree of
 9 assimilation of enterprise systems. Specifically, the amount of ERP artifactual knowledge that a company
 10 maintains regarding the ERP systems indeed results in higher assimilation. Similarly, an aspect that is
 11 peculiar to the enterprise systems context as against smaller IS applications is the importance of cross-
 12 departmental interaction routines, which is found to be significantly linked to ERP assimilation.

13 We also found support for two moderating effects out of the four that we hypothesized. First,
 14 normative pressures indeed strengthen the effect of ERP interunit coordination knowledge on assimilation.
 15 Second, mimetic pressures provide further motivation to organizations to apply their ERP artifactual
 16 knowledge for assimilating ERP systems. This is reminiscent of the motivation-capability interaction effect
 17 where highly capable individuals/organizations succeed only when they are also motivated enough.

1 As for the two remaining moderating effects normative pressures do not appear to strengthen the
2 effect of ERP artifactual knowledge on ERP assimilation whereas higher mimetic pressures lead to a
3 weakening relationship between ERP coordination knowledge and assimilation. The latter effect is quite
4 unexpected. A conjecture could be that strong mimetic pressures suppress the organizations internal
5 capabilities from manifesting themselves whereas weak mimetic pressures act as triggers for organizations
6 to draw upon their internal coordination routines to guide their assimilation efforts. Thus, weaker mimetic
7 pressures trigger mindfulness in organizations towards their ERP assimilation efforts.

8 The above findings need to be considered while being cognizant of the following limitations. First,
9 the sample size is relatively small. The moderation effects that are sensitive to sample size should be
10 confirmed with larger samples. Second, the responding firms are from a single context (China). The
11 relationships found in this study might not be readily generalized to other contexts. Future research should
12 include more firms in a wider range of contexts to confirm our research model. Third, multiple respondent
13 surveys are better at avoiding common method bias, which is missing in our data.

14 **6. CONCLUDING REMARKS**

15 The study of ERP or other complex systems presents opportunities for developing and testing an
16 integrated theory of how influences from the external institutional environment on the assimilation of
17 enterprise systems, are moderated by the learning capacity of organizations. Despite the fact that a large
18 amount of past literature elaborates on the critical success factors and specific theories, we believe that it is
19 time for a comprehensive research model to emerge from such disparate findings. As a modest effort
20 towards this end we present an integrated nomological model where external institutional pressures interact
21 with an organization's learning capabilities to eventually affect the degree of ERP assimilation.

22 **6.1. Theoretical implications**

23 Though, there is a lack of empirical studies to compare our findings with at a construct level, two
24 studies are especially related to this research. First, in the study by Armstrong and Sambamurthy (1999),

1 they did not find support for their hypothesized link between the 'system of knowing' of CIOs and top
2 management with IT assimilation. Our measures of ERP coordination knowledge resemble their construct
3 of 'system of knowing'⁸ – however our measurement is at the operational levels and is significant. This
4 suggests that perhaps in post-implementation stages the 'system of knowing' among the middle and lower
5 levels of an organization are effective in assimilating enterprise systems. Another recent study (Son et al.
6 2004) of diffusion of B2B electronic marketplaces does not find any link between institutional pressures and
7 usage. We demonstrate that a direct link indeed exists but it is not clear why our findings are inconsistent
8 with theirs. Perhaps it is due to the nature of the artifact and thus needs to be better understood in future
9 research. More importantly, our findings also suggest that perhaps the efficacy of external institutional
10 pressures at the post-implementation stages can be detected by studying its interaction with ERP-related
11 learning capability constructs.

12 This study also contributes to the innovation assimilation research by linking institutional and
13 organizational learning theories. The integrated view of institutional and organizational learning theory has
14 been called for in the literature on competitive dynamics (Smith et al. 2001). This integrated approach might
15 help to illuminate some of the inescapable dilemmas in the natural dynamics of organizational adaptation
16 (Burgelman 2002). The combination of the internal and external factors enables us to portray a more
17 complete picture of ERP assimilation. For example, for example, by itself ERP coordination knowledge
18 appears to be weakly significant ($p < 0.1$) but both its interaction effects are also significant. Considering that
19 assimilation of large-scale information systems takes place in an institutional context exposed to external
20 influences and involves heavy cognitive effort by the organization, our result suggests that the combination
21 of organizational learning theory and the institutional theory in future studies can further a richer
22 understanding of IS assimilation.

⁸ It is defined as the structures guiding interactions among senior leadership to facilitate their dialog and sharing and exchange of knowledge (page 307).

1 **6.2. Practical implications**

2 This study also bears practical implications for organizational IS development. During the ERP
3 assimilation stage, most of the know-how of the new system has been transferred from the vendors and
4 consultants to the users who are now expected to be in the self-service mode. The significant relationship
5 between ERP artifactual knowledge and ERP assimilation suggests the importance of training and support
6 during this stage and calls for organizational leaders to build the organizational capability to better acquire
7 and assimilate external knowledge. Weak support is found for the relationship between ERP coordination
8 knowledge and ERP assimilation. Yet this does not mean that a pursuit of ERP coordination knowledge is
9 trivial from a managerial standpoint. The effect of ERP coordination knowledge on the degree of ERP
10 usage will be strengthened if most functional units in the organization also possess a normative
11 understanding derived from external agencies including user workshops, conferences etc. so as to be able
12 to effectively coordinate their system usage behavior. The interdepartmental coordination capabilities can
13 be viewed as transformation and exploitation capabilities that cannot be developed easily. Without
14 moderation analysis, their interactions with the institutional context could have been overlooked. In short, to
15 materialize the promised benefits of ERP, managers have to continue to develop ERP artifactual and
16 coordination knowledge but also need to consider the levels of institutional pressures they are exposed to
17 so as to have a better understanding of the ERP assimilation process.

18 **Appendix A**

19

20 **ERP Assimilation**

- 21 1. Volume: Percentage of the firm's business processes that are using the ERP system (%)
22 2. Diversity: Number of functional areas that are using the ERP system
23 3. Depth: For each functional area identified above, identify the level at which the ERP system is
24 used:
25 a. Operation
26 b. Management
27 c. Decision making

28 **Top management participation (1 = strongly disagree; 5 = strongly agree)**

29 The senior management of our firm actively

- 30 1. ... articulates a vision for the organizational use of ERP

- 1 2. ... formulated a strategy for the organizational use of ERP
2 3. ... established goals and standards to monitor the ERP project
3 Mimetic pressure (1 = strongly disagree; 5 = strongly agree)
4 Our main competitors who have adopted ERP
5 1. ... have greatly benefited
6 2. ... are favorably perceived by others in the same industry
7 3. ... are favorably perceived by their suppliers and customers
8 Normative pressure (1 = very low; 5 = very high)
9 Please indicate:
10 1. The extent of ERP adoption by your firm's suppliers
11 2. The extent of ERP adoption by your firm's customers
12 3. The extent to which the Government's promotion of Information Technology influences your firm to
13 use ERP.
14
15

Table 6. Loadings of the Indicator Variables (Composite Reliability) (AVE)

Construct		Indicator	Mean	SD	Loading	T-value
Top management belief (.789)(.565)		TMB1	3.77	.65	.706	4.226
		TMB2	4.10	.50	.893	12.137
		TMB3	3.88	.49	.783	7.626
Top management participation (0.839) (0.636)		TMP1	3.78	.74	.829	16.509
		TMP2	3.82	.66	.866	24.730
		TMP3	3.87	.73	.716	4.515
Mimetic pressure (MIME) (0.852) (0.658)		MP1	3.34	.72	.728	6.779
		MP2	3.61	.63	.856	18.513
		MP3	3.35	.60	.844	16.492
Coercive pressure (COER) (0.902) (0.821)		CP1	3.23	.76	.902	5.590
		CP2	2.82	.70	.911	5.332
Normative pressure (NORM) (0.906) (0.762)		NP1	2.43	.83	.874	17.704
		NP2	2.77	.84	.922	35.208
		NP3	3.65	.84	.821	9.457
PACAP	PACAP1 (0.839) (0.636)	1	3.75	.84	.856	23.165
		2	3.45	.90	.845	25.295
		3	3.44	.88	.680	5.464
	PACAP2 (0.892) (0.804)	1	3.10	.89	.902	47.542
		2	3.35	.82	.892	31.429
RACAP (0.884) (0.719)		1	2.88	.88	.727	5.915
		2	3.32	.99	.913	19.678
		3	3.58	.87	.890	12.786
ERP assimilation (n/a) (n/a)		Volume	54%	21%	n/a	9.866
		Diversity	2.92	1.68	n/a	12.780
		Depth	2.60	.63	n/a	3.086

16

17

1

Table 7. Correlations among Constructs

	Construct	1	2	3	4	5	6	7	8	9
1.	TMB	.577*								
2.	TMP	.387	.637*							
3.	MIME	.209	.135	.658*						
4.	COER	.154	.454	.077	.796*					
5.	NORM	.042	-.034	-.099	.144	.763*				
6.	PACAP1	.183	.163	.132	.075	.167	.636*			
7.	RACAP	.104	.307	.359	.100	.300	.558	.719*		
8.	PACAP2	.312	.372	.352	.023	.239	.435	.465	.804*	
9.	Assimilation	.396	.522	.390	.144	.333	.412	.348	.464	n/a

2 * AVE of each construct

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