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THE ANTECEDENTS OF INFORMATION SYSTEMS DEVELOPMENT CAPABILITY IN FIRMS: A KNOWLEDGE INTEGRATION PERSPECTIVE

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Abstract

The linkages between IS and business units are recognized as being critical to information systems development processes and outcomes. Previous research has found that they are associated with better performing ISD teams, stronger alignment between firms' IT investments and business objectives, and comparatively superior exploitation of information technologies for business ends. What remains lacking in this stream is a coherent theoretical explanation for why and how the linkages between the IS unit and business units in a firm influence ISD processes and outcomes. This study draws on strength-of-ties theory to develop and test a project-level model that links both structural and cognitive IS-business linkages to ISD outcomes and processes. The key premise of this model is that IS-business linkages influence ISD primarily by facilitating integration of business and technical knowledge dispersed across internal business functions and outside the formal boundaries of the firm during the ISD process. Such integration of internal and external knowledge in turn influences ISD processes and outcomes. We tested the model using data on 133 projects collected from CIOs and client-side managers in 133 firms. Our results provide strong support for the hypothesized model.

Introduction

The successful management of information systems (IS) projects continues to challenge managers in contemporary firms (Guinan et al. 1998; McFarlan 1981). As a consequence, information systems development (ISD), or the ability to deliver IT-based business applications in a timely manner and in accordance with evolving business needs, is a critical organizational capability (Feeny and Wilcocks 1998). In particular, in environments with moderate to high degrees of business turbulence, the capability to adapt the ISD process and application to emerging business needs is a decisive imperative.

How do firms promote their information systems development capability? Researchers have conceptualized the systems development process as knowledge intensive because it requires the integration of dispersed slices of business and technical

knowledge (Curtis et al. 1988). Faraj and Sproull (2000) demonstrated that a focus on coordinating and integrating the knowledge possessed by team members contributed to enhanced project performance.

Information systems researchers have also examined the impacts of partnerships and linkages between IS and business units on ISD processes and outcomes. For example, IS-business linkages are associated with enhanced performance of the IS unit (Nelson and Coopriider 1996), improved alignment between IS investments and the business objectives of a firm (Reich and Benbasat 2000), higher levels of IT assimilation (Armstrong and Sambamurthy 1999), and superior exploitation of new information technologies for competitive differentiation (Ross et al. 1996).

The focus of this research is to integrate the above two perspectives on determinants of effective ISD capability in firms to understand how firms can institutionally promote knowledge integration in information systems development projects and, thereby, influence ISD capability. Specifically, we develop and test a model that hypothesizes a nomological network of relationships between IS-business partnerships, knowledge integration, and ISD capability. Data gathered from 133 firms are used to test and corroborate this model.

The rest of the paper proceeds as follows. The next section describes our theoretical concepts and hypotheses. Subsequently, we describe our research methodology. The final two sections present our results and discuss their implications.

Theoretical Model and Hypotheses

Figure 1 illustrates the model guiding our research. We propose that IS-business unit linkages reflect the institutional climate of partnering that motivates business and IS executives to share their knowledge within the context of ISD projects. Further, we propose that two forms of knowledge integration, internal and external, describe the quality of coordination of expertise within systems development teams. Finally, we propose that ISD capability is represented both by the adaptiveness of the process to emerging business requirements as well as by the fit of the resultant application with the business needs. We elaborate on the constructs in the model and state our hypotheses in the following sections.

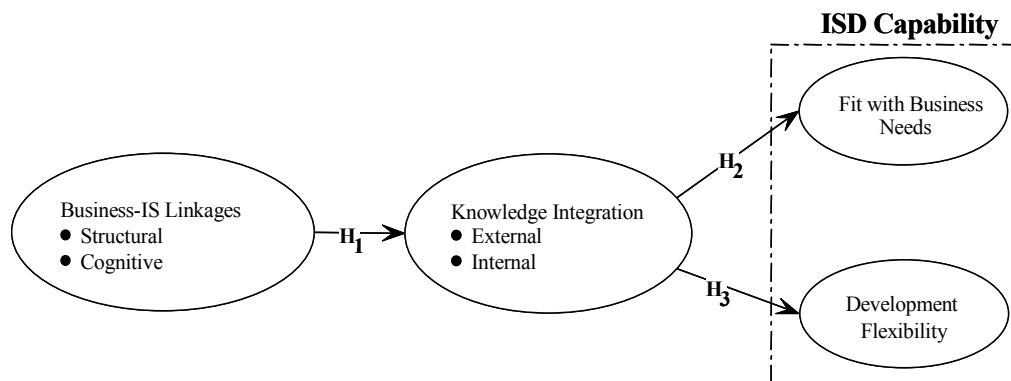


Figure 1. Conceptual Model

IS-Business Unit Linkages

The linkages between the IS unit and business units are widely recognized as a key antecedent to the superior performance of the IS unit and the exploitation of new technologies (Feeny and Willcocks 1998; Henderson 1990; Reich and Benbasat 2000). Strong linkages typify a partnering relation between the IS and the business units rather than an arms-length, transactional-style relationship. Such relationships are characterized by a sense of mutual cooperation, recognition of mutual dependency, and active collaboration (Henderson 1990). The value of strong IS-business linkages has been demonstrated at both the top management and business-unit levels (Armstrong and Sambamurthy 1999; Lind and Zmud 1991; Reich and Benbasat 2000). Since the requirements of an ISD project are derived from the expressed and inferred business needs, closer working relationships help ensure that the members of the IS group accurately understand them and that the members of the business unit realize both the

possibilities and the limitations of the associated technologies. Moreover, closer working relationships foster mutual understanding, trust, and respect—all of which influence the ISD process (Constantine and Lockwood 1993).

Granovetter's (1973) strength-of-ties theory provides the underpinnings for why IS-business unit linkages provide an institutional climate of partnering and nurture knowledge integration and ISD capability. Recent research has extended Granovetter's theory to intra-organizational settings to examine how tie strengths can facilitate or inhibit knowledge sharing across organizational subunits (Hansen 1999). Strong ties are characterized by high levels of closeness, reciprocity, and interaction. Hansen found that strong ties facilitate knowledge sharing among the organizational units, especially when the knowledge in question is tacit and cannot be codified in documents or artifacts. Some of the knowledge in the ISD process such as business unit needs and user requirements for an information system, linkages to firm strategy, and the mapping between these and the design of a system is complex and tacit. While various ISD methodologies attempt to codify such knowledge in requirements documents and other artifacts of the ISD process, they do so with lackluster success.

Intra-organizational linkages between IS and business subunits can be described in terms of their structure and content (Hansen 2002; Tsai and Ghoshal 1998). Following this characterization, we conceptualize the IS-business unit ties in terms of their structural and cognitive linkages.¹ *Structural linkages* refer to the strength and frequency of social interactions of the IS unit with internal and external business units (Nahapeit and Ghoshal 1998). Close working relationships with other business functions, business partners, and IT vendors exemplify strong structural linkages. Such linkages provide access to the necessary resources across formal lines and levels in an organization (Tsai and Ghoshal 1998). *Cognitive linkages* refer to shared mutual understanding of collective goals, business strategies, organizational work processes, and the work environment among the IS and business units in a firm. When strong cognitive linkages exist between the IT unit and the business units, they share a conceptual understanding of the role of IT in the business activities of the firm, can interrelate business and IT planning, and can appreciate each others' knowledge (Feeny and Willcocks 1998; Ross et al. 1996). An analysis of previous research on intra-organizational ties suggests that structural and cognitive linkages are dimensions of the same underlying concept (Kogut and Zander, 1992; Walsh and Ungson 1991). Structural linkages, characterized by close interactions, help create a shared point of view and common understanding (Ross et al. 1996; Tsai and Ghoshal 1998).²

Knowledge Integration

Knowledge is a key ingredient of software (Faraj and Sproull 2000; Robillard 1999; Walz et al. 1993). From the conceptualization of an embryonic ISD project idea to its implementation in software, integration of two types of knowledge undergirds successful ISD: (1) knowledge about the business needs that a system must fulfill and (2) technical knowledge that is used to translate those business needs into a software-based solution that satisfies them. Information systems development can, therefore, be viewed as a process of integrating technical and business domain knowledge in developing a solution to a business problem (Rus and Lindvall 2002). Various project stakeholders including members of the IS and business units bring a variety of skills, knowledge, and viewpoints to the ISD process. However, this knowledge by itself carries little value unless it is applied and embodied in the design and functionality of a system. Application of such knowledge to the ISD process is a socio-technical process involving multiple objectives of various project stakeholders (Iivari et al. 1998; Kirsch 1996). Its application must therefore be coherently coordinated. This is often challenging because much of the pertinent knowledge is dispersed across organizational boundaries both within and outside an organization. Moreover, some of this knowledge is "sticky" and resistant to transfer by snapshot means such as project requirements elicitation (von Hippel 1994). Nevertheless, it is through the integration of such business and technical knowledge that project stakeholders can arrive at mutual agreement about how a software system's functionality and design can support the project's business objectives. Most revealing is perhaps Constantine and Lockwood's (1993) description of successful software projects as ones that draw on and integrate the contributions of ISD project constituents into a unified, practical solution.

We define knowledge integration as the process of absorbing knowledge from external sources and blending it with the technical and business skills, know-how, and expertise that reside in the business and IS units of a firm (Grant 1996; Lawrence and Lorsch 1967; Okhuysen and Eisenhardt 2002). Others have referred to this concept of recombining existing and acquired knowledge using

¹These correspond to the social and intellectual dimensions of alignment identified by Reich and Benbasat (2000).

²This has also been demonstrated empirically by the high correlation between the structural and cognitive dimensions of interunit linkages (Tsai and Ghoshal 1998).

different labels such as knowledge combination (Kogut and Zander 1992) and knowledge configuration (Henderson and Clark 1990).

Adopting the ISD project as the focal point when knowledge integration occurs, we focus on both external and internal knowledge that is brought to bear on the ISD project (Lyytinen et al. 1998; Verona 1999). *External knowledge integration* refers to the extent to which the team integrates knowledge from outside the firm in the development process. Such knowledge relates to market needs, regulatory constraints, the external environment, and business and technical developments that affect an ISD project (Henderson 1990; Prahalad and Krishnan 2002). *Internal knowledge integration* refers to the extent to which the development team builds on the knowledge of the relevant stakeholders during the development process. The members of the team build on their collective expertise in conceptualizing the project solution, developing an accurate understanding of their expectations from the project, and identifying the key business constraints by internally integrating knowledge about them. While external knowledge integration facilitates absorption of knowledge from outside the firm, internal knowledge integration organizes its contextualized application in conjunction with internal expertise.

The Influence of IS-Business Linkages on Knowledge Integration in the ISD Process

Poor integration can be attributed to two causes. First, knowledge required to conceptualize and develop a complex system is often fragmented across different organizational units (Curtis et al. 1988). Knowledge about a project's constraints—cost, quality, functionality, divergent objectives, and acceptable tradeoffs—also originates in disparate parts of an organization. For example, technical and programming expertise might reside in the IS unit, in-depth understanding of the business problem might reside in the relevant business units, and some relevant expertise might reside outside the formal boundaries of an organization (such as with business partners, technology vendors, or suppliers). Second, tacit knowledge—such as skills, experience, and understanding—tends to be sticky and difficult to articulate (von Hippel 1994). Such stickiness is especially pronounced across functional specialties (Postrel 2002). Therefore, the project requirements that are elicited at the outset of a project are likely to oversimplify reality and provide an incomplete picture of its business needs. Moreover, requirements can drift over the project's course. Although there is considerable debate about the value of strong and weak ties, there appears to be consensus that strong ties increase the likelihood that organizational subunits will share sensitive information with each other (Hansen 1999). Access to knowledge about the business application domain and needs of the business unit directly influence whether an ISD project can embody those needs. Strong structural and cognitive linkages between business and IS units facilitate integration of such knowledge with the technical knowledge held in the IS unit.

Structural business-IS linkages shape knowledge integration in two ways: (1) they provide channels for knowledge flows, and (2) they increase incentives for cooperative knowledge sharing. First, the stronger the ties among organizational subunits, the lower the cost of sharing knowledge among them (Hansen 2002). Such knowledge relates to both knowledge about the business units' needs and the external knowledge that the business unit has access to. Much of this knowledge is sticky and is therefore harder to fully articulate in early artifacts of the ISD process such as requirements documents. The separation imposed by the formal boundaries that separate the IS unit from other business units can hinder the development of a shared understanding of the project (Curtis et al. 1988). The more these stakeholders interact with each other formally and informally, the greater the extent to which they iteratively refine project concepts, ideas, and designs as the project progresses. Second, integration of knowledge also requires willingness to contribute to the project on the part of the business units that possess it. Strong structural ties increase incentives for cooperative information sharing and enhance the development of shared understanding among the IS and business units (Szulanski 1996; Yli-Renko et al. 2001).

The cognitive dimension of IS-business linkages influences knowledge integration in three ways: (1) it provides a shared context for knowledge application, (2) it facilitates communication and coordination, and (3) it raises the capacity of the IS unit to absorb new information. First, strong cognitive linkages are associated with higher levels of shared mutual understanding. Such shared understanding establishes implicit rules and mechanisms for coordination of the inputs to the project from the IS and business units (Kogut and Zander 1992), which facilitates coordinated application of their members' knowledge. Second, a shared understanding that embodies that the collective goals of the business units in a firm guide the formulation of an organizing vision for ISD (Swanson and Ramiller 1997). Business units that share a vision with the IT unit are more likely to share and exchange their resources because they are better able to envision the potential value of their recombination (Tsai and Ghoshal 1998). In contrast, when project stakeholders and participants have limited cognitive overlaps, the perspectives and ideas that they do not share are difficult to discuss (Rulke and Galaskiewicz 2000). Third, members of the IS and business units are likely to be embedded in different social and professional networks and are therefore less likely to share the norms and language for sharing knowledge (Powell et al. 1996). Cognitive linkages among them enhance intra-organizational absorptive capacity, i.e., capacity of the IS unit

and business unit to interrelate to each others' domain and expertise (Van den Bosch et al. 1999). This facilitates interpretation of new information that emerges during the development process. Moreover, the business units with which the IS unit shares cognitive linkages serve a receptors of external information that members of the IS unit might be unable to interpret. Strong cognitive linkages enhance the ability of the members of various business units to communicate such information to the IS unit and the IS unit to communicate emerging technical developments to the business units (Ross et al. 1996). Although such cognitive linkages have not been explicitly recognized in previous research, field studies strongly hint at their value to managing the ISD process (Armstrong and Sambamurthy 1999; Ross et al. 1996).

In summary, IS-business linkages open up opportunities to exchange and recombine ideas, skills, and resources that are otherwise fragmented across organizational units. We therefore hypothesize that IS-business linkages enhance the ability of the development team to filter, absorb, incorporate, and apply the pertinent technical knowledge and business knowledge to the ISD process.

Hypothesis 1: *The linkages between the IS unit and the business units directly and positively influences knowledge integration at the IS project level.*

ISD Capability

ISD capability is defined as the extent to which the IS unit can consistently deliver IS solutions that meet the firm's evolving business needs.³ The information systems development capability is assessed in terms of the outcomes as well as the nature of the process of information systems development. An IS project's fit with business needs is one of the important outcomes of ISD and represents the extent to which a system meets its business needs at the time of its delivery (Krishnan and Ulrich 2001; Rai et al. 2002). Knowledge integration enhances fit for three reasons: (1) it helps integrate diverse functional perspectives and expertise in formulating a solution, (2) it reduces conflict among project stakeholders, and (3) it facilitates attention shaping. First, the stakeholders in an ISD project not only know different things but also know things differently. Each stakeholder may have a different view of the factors that should be considered in devising a software solution. Conflicting interpretations of a project's goals can lead to design decisions that are incompatible with the project's objectives (Cooper 2000; Orlikowski 2002). The widespread problems of unmet requirements, incorrect solutions, and user-rejected systems that plague ISD can all be traced back to poor integration of knowledge, much of which might be available during the ISD process. Lack of goals that are shared by the project's constituents leads to fragmented efforts, which are a leading cause of failed ISD projects (Ewusi-Mensah 1997). However, when functional perspectives from different thought worlds are integratively brought to bear on the ISD process, it is more likely that the resulting solution will appropriately embody the business needs. In a study of 17 scientific software development projects, costly mistakes or "glitches" were traced back to poor inter-functional integration of knowledge about problem constraints (Hoopes and Postrel 1999). Therefore, internal knowledge integration facilitates coordinated exploitation of the ideas, skills, information, and understanding of the members of both the IS and business unit across all stages of the ISD process. Integration of external knowledge further ensures that the technical choices made during the ISD process correspond to the evolving business environment. Second, opportunities for conflict arise when the system's business stakeholders do not appreciate the technical constraints of the technology or the members of the IS unit do not fully comprehend the business needs that the project must fulfill (Curtis et al. 1988). On the other hand, successful projects integrate technical knowledge with knowledge of the business processes and activities that a system must support (Cooper 2000; Walz et al. 1993). Knowledge integration also enhances the level of trans-specialist understanding, which helps develop an accurate shared understanding of the business problem that a system is intended to solve, its goals, scope, and constraints (Postrel 2002). Third, knowledge integration helps shape attention to the features, functionality, and constraints that are most relevant to deriving business benefits from the system. Furthermore, integration of external knowledge raises the cognizance of the IS unit to external technological and market developments that might affect the project. Such shared conceptualizations about a problem under consideration and its potential solutions help sustain coordinated action. In summary, knowledge integration creates harmony of purpose and coherence between business and technical agendas during the ISD process.

Hypothesis 2: *Knowledge integration directly and positively influences an IS project's fit with business needs.*

We define *development flexibility* as the extent to which new requirements and design changes can be incorporated throughout the project's development trajectory. Flexibility during the development process determines how costly it will be to make changes

³Unlike the software engineering/capability maturity model perspective on capability, our definition of ISD capability refers to organizational capability and is subsumed by the firm's larger portfolio of IT capabilities (see Sambamurthy et al. 2003).

to the project once information warranting change has been identified (Athey and Schmutzler 1995). It lowers the cost of incorporating unanticipated changes in business and market needs in the design of the system. It involves deferring commitment to an unchangeable design while continuing development concurrently with the validation of project concepts across each stage of development.

Flexibility in the ISD process is valuable because it allows changes to be incorporated in a project either in response to new information or to accommodate business needs that were not accurately identified at the outset of a project. First, the business needs of a project can evolve over its trajectory (Krishnan and Ulrich 2001; MacCormack et al. 2001). Such change might be warranted by changes in the market needs or technology underlying a project (Krishnan and Bhattacharya 2002). Low flexibility might lead to the systematic rejection of unproven but potentially promising ideas and technologies that emerge during the development process and might enhance the software. Development flexibility is particularly germane in dynamic business environments where the somewhat linear approach that undergirds widely used ISD methodologies can impede adaptation of the project. Second, considerable uncertainty surrounds the initial ISD design decisions (Curtis et al. 1988). Some of this uncertainty stems from the difficulty in accurately specifying the business needs from which the preliminary solution is devised at the outset of a project. Therefore, new requirements can surface during the development process through feedback during user reviews, customer walkthroughs, and via prototypes. The London Stock Exchange's TAURUS project and the Denver Airport's baggage handling system are widely known examples of ISD projects that failed because of the inflexibility of the development process.

Next, consider how knowledge integration influences flexibility. Flexibility implies an ability to incorporate a change or modification in the system in response to new information such as changing business needs or market developments. This requires that information that warrants such changes is recognized and brought to bear on the ISD process. Much of this information is dispersed across organizational subunits that hold a stake in a project. Flexibility is increased by mechanisms that improve the use of knowledge that is dispersed among the organizational subunits that are attuned to such changes (Athey and Schmutzler 1995). Integration of external knowledge provides a mechanism through which information about exogenous changes can be applied to a project. Similarly, information about endogenous changes such as drifts in business needs or changing user needs is incorporated by internal integration of such knowledge. Moreover, when members of the IS unit are cognizant of the constraints outside their domains of expertise and recognize the relevant dependencies, incorporating a change is easier. When the pace of such change is rapid and unpredictable, adapting the ISD process to address it necessitates a shorter lag between the time when the pertinent information becomes available and the time it is considered in the context of a project (Dyba 2000). Formal knowledge-transfer mechanisms such as change requests or revised requirements specifications rarely allow rapid incorporation of such information. In contrast, knowledge integration focuses more on the application than the transfer of knowledge. It therefore facilitates rapid reworking of existing designs and project concepts to accommodate such changes.

***Hypothesis 3:** Knowledge integration directly and positively influences ISD flexibility.*

Although IS-business unit linkages create the potential for new recombinations of business and technical knowledge during the ISD process, it is the extent to which such knowledge is integrated and applied that engenders superior ISD performance. While such linkages influence the outcomes and processes of ISD, we argue that they do so primarily because they facilitate knowledge integration. This logic is grounded in Zahra and George's (2002) observation that it is not the extent to which the potential for recombining knowledge exists that impacts organizational activities but the extent to which such combinations are realized. We therefore expect that the effects of IS-business unit linkages on project success and development flexibility are fully mediated by knowledge integration.

Previous research has shown that increasing project size increases a project's exposure to risk (Lyytinen et al. 1998). As a result, managers are more likely to rely on techniques such as design freezes and unchangeable requirements, thereby reducing development flexibility (Keil and Montealegre 2000). Similarly, projects on a longer development schedule are more likely to encounter changing requirements and business needs. Therefore, they are less likely to successfully meet their business needs as they evolve toward the end of the project. To rule out these alternative explanations, we used project size and duration as control variables.

Methodology

Data for testing the hypothesized model were collected using a field survey that tapped two key informants at each sampled firm: the CIO and a manager in the business unit for which the system was developed. In the first phase, we contacted the CIO of each firm in our sample. In the second phase we collected additional data on project outcomes from a business manager in each firm

whose CIO participated in the first phase. While we measured IS-business linkages at the organizational level, we asked respondents to refer to a recently completed IS project while providing responses about the other constructs. Data were gathered from 133 firms with an effective response rate of about 21.4 percent across both phases. The response rate is quite comparable to other surveys that have targeted top management or C-level executives such as ours. We conducted tests of nonresponse and late response to provide assurance that the data were not biased.

Construct Operationalization

All constructs in the survey were measured using multi-item scales with seven-point Likert anchors, as summarized in Table 1.

Table 1. Summary of the Key Constructs and their Measures

Construct	Scale type	Items	CIO	Client	Scale based on...
Business-IT Structural Linkages	Likert	3	•		(Henderson 1990; Ross et al. 1996; Tsai and Ghoshal 1998)
Business-IT Cognitive Linkages	Likert	4			(Nelson and Coopriider 1996; Prahalad and Krishnan 2002; Ross et al. 1996)
External Knowledge integration	Likert	4			(Constantine and Lockwood 1993; Robillard 1999; Rus and Lindvall 2002; Walz et al. 1993)
Internal Knowledge integration	Likert	7	•		(Grant 1996; Okhuysen and Eisenhardt 2002)
Fit with business needs	Likert	7	•	•	(Krishnan and Ulrich 2001; Rai et al. 2002)
Development Flexibility	Guttman	5	•		—
Project Size	Self-report	1	•		—
Project Duration	Self-report	1	•		—

IS-Business Linkages

IS-business linkages were measured by assessing both structural and cognitive linkages between the IT unit and the business units in the context of a given ISD project. The construct was measured reflectively by two multi-item scales for structural linkages and cognitive linkages. The reflective conceptualization of this construct is based on empirical findings that structural and cognitive linkages covary and exhibit a strong relationship (Tsai and Ghoshal 1998).

Structural linkages. The measure was derived from Hansen’s (2002) measure for structural ties among organizational subunits and Tsai’s (2001) related measure for structural linkages in intra-organizational departments. The items were adapted to an ISD context to assess in the context of a given project the linkages that characterize the IS-business working relationship. Additionally, we included items that assessed the degree of interactions among members of the IS unit and the firm’s external partners (Henderson 1990) as well as the firm’s internal business functions (Reich and Benbasat 2000; Ross et al. 1996). The final measure used three items that tapped into the extent to which members of the IT unit had a close working relationship with members of internal business functions within the firm, the firm’s business partners, and the firm’s IT partners such as software vendors and consultants who worked on the ISD project.

Cognitive linkages. The measure for *cognitive linkages* was based on Nelson and Coopriider’s (1996) two-item scale for shared understanding among the IS and business units. We expanded this scale by sampling the domain of this construct in existing literature on IS-business cognitive linkages (Pralhad and Krishnan 2002; Reich and Benbasat 2000; Ross et al. 1996). This sampling suggested the following indicators: whether IT is an integral part of business strategy (Pralhad and Krishnan 2002); a shared and mutual understanding of how IS fits into the larger goals of the firm (Pralhad and Krishnan 2002; Ross et al. 1996); and the extent to which the members of the business unit and the IS unit exhibited mutual appreciation of each others’ work domains, problems, needs, and priorities (Nelson and Coopriider 1996; Reich and Benbasat 2000). The final measure used four items that measured the extent to which the CIO perceived that members of the top management team understood the business value of IT, the extent to which managers in the business and IS unit shared a common understanding of the role of IT, the extent

to which business strategic planning was tightly integrated with IT strategic planning, and the extent to which members of various business functions understood the work environment such as the problems, tasks, and roles of the IT unit.

Knowledge Integration

Knowledge integration was operationalized as a second-order construct that was measured formatively by integral and external knowledge integration. In this study, we adopted an outcomes-based approach for knowledge integration wherein we assessed the extent to which internal and external integration of knowledge occurred over the course of an ISD project.

External knowledge integration. We identified the types of external knowledge that are relevant to an ISD project based on a review of the literature (Constantine and Lockwood 1993; Robillard 1999; Rus and Lindvall 2002; Walz et al. 1993). The final scale used four items that assessed the extent to which external knowledge about the following was integrated during the ISD process: new market developments, deployment of new information systems by competitors, and new technical developments and technologies that emerged during the development process.

Internal knowledge integration. We began with Grant's (1996) and Okhuysen and Eisenhardt's (2002) descriptions to identify a preliminary pool of indicators of internal knowledge integration. We then examined the existing studies of knowledge integration in the ISD context to frame these items in an ISD context (Faraj and Sproull 2000; Iivari et al. 1998; Kirsch 1996; Walz et al. 1993). The final scale consisted of seven items that tapped into the extent to which members of the IS and business units build on each others' ideas, skills, and expertise; engaged in joint problem solving over the course of the project; accurately understood mutual constraints; developed convergent expectations about the project; and integrated their perspectives and developed a shared understanding about the project's objectives.

Fit with business needs was measured using a seven-item semantic differential scale that assessed whether the completed system was on target with respect to its business needs, whether it added value to the firm, whether the solution was considered appropriate and worth the investment, how well the system met user expectations, the fit between the system and its business objectives, and whether the system fulfilled its business needs. This approach allows comparability across different types of projects in different organizational contexts and types of ISD projects. This scale was used to obtain assessments from both CIOs and the business manager.

Development flexibility. Development flexibility was measured using a Guttman scale that captured the extent to which new requirements and design changes could be incorporated during the following stages of the ISD process: requirements analysis, high-level design, detailed design, development and coding, and unit and systems-level testing.

Control variables. Project size was measured using a single, self-reported count of the number of individuals who were involved in a project. Project duration was measured as the scheduled length of the project measured in months. Data on the control variables were obtained from the CIO.

Analysis and Results

We used the partial least squares (PLS) approach to first assess our psychometric (measurement) model and then the theoretical (structural) model. This technique is appropriate because of the existence of some formative constructs in our model (Chin 1998). The conservative sample size requirements for PLS models are 10 times the largest number of paths entering the most complex construct (Chin and Newsted 1999). Our sample of 133 projects exceeds this threshold by a factor of over two. Model assessment was conducted in two steps. First, the measurement model was assessed and then the structural model was tested. Each one of the constructs exhibited the needed internal consistency, convergent validity, and discriminant validity⁴ (Tables 2 and 3).

Having confirmed the psychometric properties of the six multi-item scales in our model, the next step was to assess whether the two second-order factors—IS-business linkages and knowledge integration—were measured reliably by their first-order indicators. IS-business linkages were measured using two reflective first-order multi-item scales that assessed the structural and cognitive dimensions of these linkages. The loadings of the structural dimension ($\beta = 0.86$, T-value = 9.64, $p < 0.001$) and the cognitive

⁴Space limitations preclude a complete discussion of the psychometric properties of the measures.

dimension ($\beta = 0.82$, T-value = 9.07, $p < 0.001$) were statistically significant, indicating that they reliably measured this construct. Knowledge integration was conceptualized as a second-order formative construct measured by internal and external knowledge integration. The weights of both internal knowledge integration ($\beta = 0.797$, T-value = 5.30, $p < 0.001$) and external knowledge integration ($\beta = 0.35$, T-value = 1.99, $p < 0.05$) were statistically significant.

The next step in testing the hypothesized model is to assess the relationships among various latent constructs in the PLS structural model. Paths in this model are interpreted as standardized regression weights and the loadings on each construct as loadings in principal component analyses. A bootstrapping procedure with replacement using 500 subsamples was used to estimate the statistical significance of the parameter estimates. Tests of individual hypotheses in the model relied on an examination of the size, sign, and statistical significance of the path coefficients in the structural model. All statistical tests were assessed at the 5 percent level of significance using one-tailed t-tests because our hypotheses were unidirectional. A summary of these results is presented in Figure 2.

Table 2. Construct Intercorrelations and Evidence for Discriminant Validity

	1	2	3	4	5	6	7	8
Structural linkages	0.748							
Cognitive linkages	0.440	0.850						
Internal knowledge integration	0.190	0.221	0.800					
External knowledge integration	0.223	0.276	0.572	0.748				
Project Success	0.400	0.330	0.395	0.158	0.755			
Development Flexibility	0.198	0.175	0.308	0.321	0.269	0.781		
Project Size	0.098	0.085	-0.083	0.118	-0.036	-0.144	1.00	
Project Duration	0.040	0.125	-0.077	0.050	-0.149	0.087	0.262	1.00

Shaded diagonal elements are the square root of the shared variance between the constructs and their measures. Off-diagonal elements are the correlations between the different constructs.

Table 3. Psychometric Properties of the Key Constructs

Construct	Mean	σ	# Items (PLS Loadings ^a [T-statistic])	ICR	ρ_{vc}
Structural linkages	5.16	0.99	4(.84[20.14], .79[13.96], .76[9.71], .57[4.92])	0.89	0.56
Cognitive linkages	5.08	1.24	5(.89[28.71], .85[19.17], .89[30.14], .87[39.06], .75[15.87])	0.88	0.73
Internal knowledge integration	5.87	0.82	7(.80[11.06], .80[12.21], .86[20.17], .68[6.40], .74[9.25], .87[20.04], .83[20.99])	0.94	0.64
External knowledge integration	5.21	1.06	4(.86[21.6], .72[6.85], .81[14.97], .58[4.6])	0.71	0.56
Fit with business objectives	6.10	0.69	7(.73[14.22], .55[3.46], .84[24.21], .82[20.42], .63[6.53], .85[20.62], .83[16.4])	0.94	0.57
Development flexibility	5.03	1.08	5(.87[15.82], .90[16.21], .91[24.54], .73[8.68], .55[4.46])	0.85	0.61
Project size	15.43	31.15	Single item measure	—	—
Project duration	10.5	6.87	Single item measure	—	—

ICR = Fornell and Larcker’s (1981) internal consistency reliability; ^a $p < 0.001$

Business-IS linkages had a significant, positive relationship with knowledge integration ($\beta = 0.32$, T-value = 3.53, $p < 0.001$), supporting Hypothesis 1. Knowledge integration had a significant, positive effect on fit with business needs ($\beta = 0.41$, T-value = 3.42, $p < 0.001$), supporting Hypothesis 2. The relationship between knowledge integration and development flexibility was also positive and significant ($\beta = 0.33$, T-value = 4.14, $p < 0.001$), supporting Hypothesis 3. Finally, our nomological network argues that knowledge integration will mediate the impact of IS-business linkages on ISD capability. To test this assertion, we tested the direct effects of IS-business linkages on the two dependent variables. The relationship between IS-business linkages

and fit with business needs ($\beta = -0.207$, T-value = -1.59 , n.s.) and development flexibility ($\beta = -0.112$, T-value = -1.16 , n.s.) was statistically nonsignificant. Therefore, the effect of IS-business linkages is fully mediated by knowledge integration. Of the control variables, project size had a negative and significant relationship with development flexibility ($\beta = -0.138$, T-value = -2.08 , $p < 0.05$) and the duration of the ISD project had a negative and significant relationship with fit with business needs ($\beta = -0.216$, T-value = 2.82 , $p < 0.001$). The relationship between development flexibility and fit was positive but nonsignificant ($\beta = 0.07$, T-value = 0.89 , n.s.).

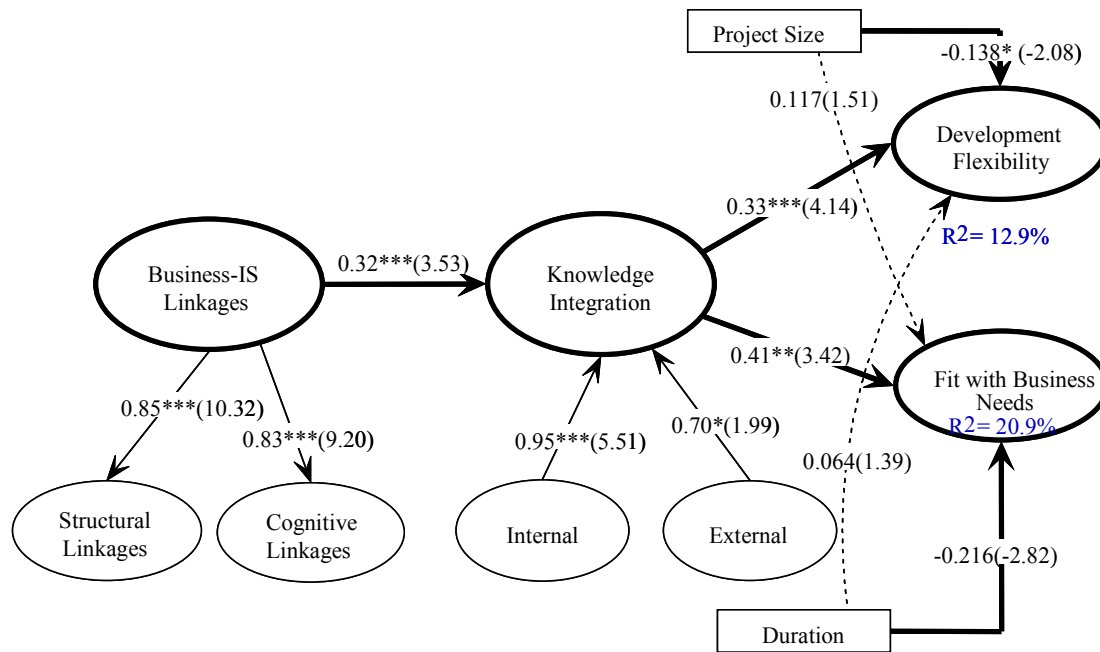


Figure 2. Results

Since PLS does not generate an overall goodness of fit, the predictive validity of the model can be assessed by estimating the total amount of variance explained by it (R^2) and by computing Geisser’s (1975) predictive validation index, Q^2 . Our model explained 20.9 percent of the variance in fit with business needs and 12.9 percent of the variance in development flexibility. IS-business linkages alone explained 10.1 percent of the variance in knowledge integration. Next, we computed the predictive relevance index Q^2 for our model. We used a blindfolding procedure that omits part of the data for a given block of indicators and then attempts to estimate the omitted part based on existing estimates. Only prime numbers less than the sample size can be used for such omission distances. The Q^2 estimates obtained for project success using omission distances of 11, 31, and 41 were 0.313, 0.523, and 0.429. The average Q^2 value across all three model reruns was 0.422, which suggests that our model has high predictive relevance for ISD project success (Chin 1998; Falk and Miller 1992). Using the same omission distances, we obtained Q^2 estimates of 0.479, 0.356, and 0.428 for development flexibility (average Q^2 across the three runs = 0.421). Together, these R^2 and Q^2 values suggest that the model predicts ISD project success and development flexibility reasonably well.

Discussion and Conclusion

Overall, the results of this research provide good support for the argument that knowledge integration fully mediates the relationship between business-IS linkages and IS development capability. Our results suggest that organizational investments in developing tight linkages between the IS community and business users should ultimately pay off through greater success at the IS project level. While prior research has emphasized the strategic importance of such linkages and examined its association with various firm level outcomes (e.g., IT assimilation and competitive differentiation) this study provides a more fine-grained analysis at the project level, where the effects of such linkages can be expected to be more direct and immediate. The two dimensions of business linkages, *structural* and *cognitive*, tap into the strength of social interactions between the IS and business communities and the shared mutual understanding between the two groups. While one would expect better linkages to result in superior project performance, our results show that these linkages can add value only when firms successfully leverage these linkages to effect

knowledge integration at the project level. This is an interesting finding that suggests firms cannot stop with merely developing linkages but have to ensure that business-IS linkages are effectively brought to bear at the project level through the critical process of knowledge integration.

Results from this study show that it is critical for firms to integrate both external and internal knowledge during IS development. The external knowledge integration capability focuses on the project team's ability to dynamically sense and comprehend the cues from the external environment (e.g., changes in customer needs and technological developments) that could impact the IS project, while the internal integration capability ensures that the project team taps into the internal resources for expertise sharing and contextualization of knowledge needed for ensuring ISD success.

Despite the large body of research and the cumulative knowledge regarding IS development efforts, it remains a complex activity that often fails to yield any value to the investing firm. Much of the existing work focuses on project-level antecedents to ISD success. The study presented here provides a conceptual framework for investigating the effects of organizational-level capabilities such as business-IS linkages on ISD process and outcome. In future work, more comprehensive models that combine firm-level and project-level antecedents of ISD success should be attempted. While our study explored the structural and cognitive aspects of linkages, other studies have shown that a third dimension, namely, trust and trustworthiness (Tsai and Ghoshal 1998), implicit in these linkages might be important as well. More trusting relationships might ease the process of knowledge integration by inducing joint efforts and easing fears of opportunistic behaviors.

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