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Complementarities Between Organizational IT Architecture and Governance Structure

Amrit Tiwana
Terry College of Business, University of Georgia, Athens, Georgia 30602, tiwana.mac@gmail.com
Benn Konsynski
Emory University, Atlanta, Georgia 30322, benn.konsynski@bus.emory.edu

This study addresses the theoretically neglected interplay between organizational information technology (IT) architecture and IT governance structure in shaping IT alignment. We theoretically develop the idea that IT architecture modularity helps sustain IT alignment by increasing IT agility, and that decentralization of IT governance strengthens this relationship. IT architecture therefore complements IT governance structure. Tests of the proposed mediated-moderation model using data from 223 organizations support these ideas. Implications for theory and practice are also discussed.

Key words: modularity; information technology architecture; governance; mediated moderation; alignment; IT strategy; IT agility
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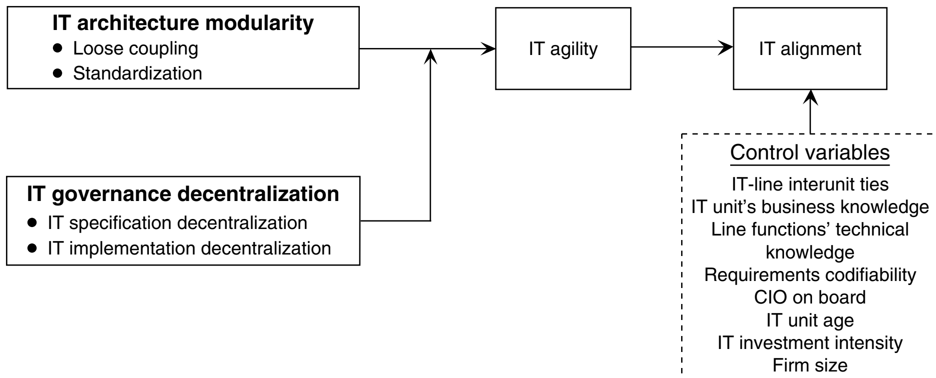
1. Introduction

The growing pervasiveness of IT-enabled business processes in contemporary organizations has heightened the importance of aligning IT activities with organizational goals and aspirations. IT alignment ensures that organizational IT activities support organizational objectives, a goal that managers often find elusive (Marwaha and Willmot 2006). Prior research has often narrowly viewed IT alignment as a "static end-state" where IT strategy exhibits fit with organizational imperatives (Sabherwal et al. 2001). Maintaining IT alignment is instead a dynamic, ongoing process that is driven by adaptive correction of emergent misfits between IT activities and perpetually evolving organizational imperatives (Hirschheim and Sabherwal 2001). For example, the Korean automaker Hyundai had historically competed on cost leadership, but recently decided to instead reposition itself in the U.S. market on quality and service. Hyundai's IT applications used by its nationwide dealer network then needed to support its new market aspirations, providing dealers with the information and tools to enable them to provide customers with an experience that supported the image that Hyundai was attempting to cultivate. Sustaining IT alignment therefore increasingly demands IT organizations and IT architectures that are designed to be adaptive and agile, especially because organizational business processes are often inextricably enabled or constrained by IT (Prahalad and Krishnan 2002). IT agility therefore plays a critical but underappreciated role in sustaining IT alignment.

Prior IT alignment research has emphasized the importance of IT governance structures (e.g., Weill and Ross 2005), but has largely neglected the role of organizational IT architecture (the "IT artifact") in facilitating IT alignment. IT architecture refers to the overarching structure and properties of the relationships among the systems and applications in an organization's IT portfolio. IT architectures provide organizations a foundation for becoming more agile—a subtlety recognized in practice but not in theory development (e.g., Hagel and Brown 2005). In particular, IT architecture modularity—the degree to which an organization's IT portfolio is decomposed into relatively autonomous subsystems—can plausibly foster

Figure 1 Conceptual Model for the Research



agility by decreasing the need for overt coordination among organizational subunits. Modular IT architectures such as Web services and service-oriented architectures (SOA) are therefore being championed by industry thought leaders (e.g., Hagel 2002). Dell, Nike, and Li & Fung are frequently touted in the media as examples of organizations that use modular IT architectures to enhance their market responsiveness.

We believe that the benefits of modular IT architectures are enhanced when they are complemented by consonant IT governance structures. Because IT architecture and IT governance structure have rarely been studied together, their causal pathways and interactions in shaping IT alignment remain theoretically underdeveloped. In other words, our understanding of how IT architecture choices interact with IT governance choices, and about the mechanisms through which they influence IT alignment, is embryonic. These gaps are also of considerable practical significance because they pertain to how managers can design the technological and organizational aspects of IT functions to sustain IT alignment. The objective of this paper is to address these gaps, guided by the following research question:

How do organizational IT architecture modularity and IT governance structure—independently and jointly—influence IT alignment?

In a departure from prior research, we introduce a dual-pronged approach that simultaneously emphasizes the roles of IT architecture and IT governance structure in facilitating IT alignment. We build on modular systems theory to first theorize how the technological architecture of the IT function ("IT architecture modularity") enhances IT alignment by fostering adaptiveness to emerging line function imperatives ("IT agility"). Second, we theorize that increasing decentralization of IT governance enhances the benefits realized from increasing organizational IT architecture modularity. Empirical tests using data collected from 223 organizations support these ideas. The paper's central contribution is showing *how* IT architecture complements IT governance in shaping IT alignment.

The remainder of the paper proceeds as follows. The next section develops the hypotheses, followed by the research methodology (§3), the analyses (§4), and a discussion of the results (§5).

2. Theory Development

Modular systems theory provides the theoretical foundation for the proposed research model (Figure 1), which is developed next. We theorize how organizational IT architecture modularity: (1) enhances IT alignment by fostering IT agility (mediation) and (2) is complemented by IT governance decentralization (mediated moderation).

2.1. Modular Systems Theory

Modularity is a general design principle that intentionally increases independence among the subsystems of a complex system (Sanchez and Mahoney 1996). The notion of modularity is grounded in Simon's (1981) premise that any complex organization or technological system is composed of distinct interacting subsystems that are to some extent interdependent and independent. Interactions between the subsystems of a modular system are significantly weaker than those within them (Ethiraj and Levinthal 2004). A system with no (strong) interactions between subsystems therefore represents a perfectly modular (integral) system. Because neither extreme is observed in practice, it is more meaningful to conceptualize modularity as a continuum. The crux of modular systems theory is that greater modularity facilitates rapid changes in individual subsystems by lowering the need for coordinated changes in others (Schilling 2000).

Modularity can be a technical and organizational characteristic; the two facets correspond to technical and organizational modularity (see Langlois 2002). Modularity can therefore characterize both the technological architecture and organizational structure of the IT function. Therefore, organizational IT architecture and IT governance structure, respectively, represent the technical and organizational facets of IT function modularity.

2.2. IT Architecture Modularity

An organization's IT architecture refers to the arrangement through which various software applications and subsystems are interlinked (Kruchten et al. 2006). According to Sanchez and Mahoney (1996), modularity is achieved by increasing loose coupling among subsystems and standardizing their interfaces. We therefore define *IT architecture modularity* as the degree of decomposition of an organization's IT portfolio into loosely coupled subsystems that communicate through standardized interfaces. *Loose coupling* refers to the degree to which the applications in an organization's IT architecture are designed such that internal changes in one application do not affect the behavior of others (Fowler 2001, Nambisan 2002). Examples of commercialized loosely coupled IT architectures include Web services, Simple Object Access Protocol (SOAP), XML, and CORBA (Hagel 2002). *Standardization* refers to the degree to which organizationwide standards and policies prespecify how applications in an organization's IT portfolio connect and interoperate with each other (Weill and Ross 2005). For example, Web services description language (WSDL) provides standards for describing a Web service and application programming interfaces (APIs) describe standards for interoperating with specialized software applications.

IT architecture loose coupling and IT standardization represent distinct, but not necessarily covarying, dimensions of IT architecture modularity. In other words, an increase in either dimension increases architectural modularity but does not *necessarily* increase the other dimension. For example, it is plausible that IT standards are widely prescribed and enforced in an organization, yet IT applications are tightly coupled. Similarly, an organization might use a variety of standalone IT applications for order management, manufacturing, design, and customer relationship management that do not conform to a common set of standards. Therefore, IT standardization and IT loose coupling represent the underlying *formative* dimensions of IT architecture modularity. (We subsequently also do a robustness check using a competing reflective conceptualization.)

2.2.1. The Influence of IT Architecture Modularity on IT Alignment. *IT alignment* is defined as the degree to which the IT function supports the goals and priorities of an organization's line functions (Chan and Reich 2007, Sabherwal et al. 2001). For example, Wal-Mart competes on cost leadership and UPS on operational efficiency. Wal-Mart's IT investments in its supply chain and UPS' investments in its mobile telecommunications and logistics systems must (and do) support their distinct business imperatives. IT alignment, however, can be a moving target, and it is relatively easy for the IT function to slip out of alignment (Hirschheim and Sabherwal 2001). As our introductory Hyundai example illustrates, changes in user expectations, business processes, organizational priorities, and competitive pressures can lead to rapidly changing line function IT needs and present new opportunities (Prahalad and Krishnan 2002). Maintaining alignment thus requires the capacity to rapidly adapt to such emergent changes in business needs. We define this capacity of the IT function to rapidly adapt to changing line function demands as *IT agility*, building on Sambamurthy et al. (2003).

IT agility is a critical antecedent to IT alignment for two reasons. First, it facilitates rapid correction of emergent misalignments between IT activities and line function demands (Prahalad and Krishnan 2002). Because many line function business processes rely heavily on IT applications, the inability to rapidly adapt these applications can impede changes to existing business processes.[1] Second, it allows the IT function to be responsive to new market opportunities encountered by the line functions (Hagel 2002). For example, organizations might rapidly introduce enhancements to their IT applications to support new line function business processes.

An impediment to IT agility is that a change in one application in an organization's IT portfolio might require simultaneous changes in—at least awareness of—other applications with which that application exchanges data (Parnas 1972). Changing interconnected, customized IT applications is therefore often difficult and time consuming (Marwaha and Willmot 2006).[2] IT architecture modularity can mitigate these coordination bottlenecks to IT agility in two ways. First, it increases application-level autonomy, i.e., changes *within* one application are less constrained by dependencies with others. IT architecture modularity lowers cross-application interdependencies by isolating perturbances from one application to others ("encapsulation") (Zweben et al. 1995). (Encapsulation refers to the property wherein one application does not depend on or need to know how another application performs its internal functions.) Furthermore, standards prespecify details for attachment, information exchange, and interactions among various applications. Such encapsulation lowers the need for time-consuming iteration and overt coordination among the line functions that an application spans. This permits rapid improvisation of individual applications without concern about compromising their interoperability or causing unanticipated disruptions in other interacting applications. Second, modularization facilitates rapid exploitation of new software applications based on emerging technologies, which can seamlessly interoperate with existing applications simply by complying with the established organizationwide IT standards. In this sense, IT architecture modularity enhances the potential for rapid incremental innovation at the application level by lowering cross-application dependencies.

Consider the example of Hong Kong-based apparel manufacturer Li & Fung, whose clients include Levi Strauss, Reebok, Zara, and Kohl's. Li & Fung uses a modular (Web services) IT architecture to electronically coordinate production processes with 7,500 suppliers in 40 countries. If a production problem arises in any country, it can rapidly switch suppliers or add a new supplier. The modular interfaces of Li & Fung's production coordination system allow rapid integration of supplier production-monitoring systems without forcing suppliers to change their internal IT applications. Instead, each supplier can use Web services standards to implement loosely coupled interfaces for their existing applications and databases with other business partners in Li & Fung's network. Such IT agility resulting from a modular IT architecture allows Li & Fung to continuously align its IT with business priorities, and has contributed to its above-industry margins, shorter cycle times, and above-industry growth rate (Hagel and Brown 2005). In a similar vein, online stockbrokers such as E*Trade are using modular IT architectures to integrate a rich array of specialized third-party information (e.g., analyst reports, technical charts, and macroeconomic data) in highly tailored ways for high net worth investors. Modular (SOA) architectures enable them to integrate a more diverse array of resources for their investors, allowing stockbrokers to experiment with new ways of combining data and financial modeling techniques (Hagel and Brown 2005). Based on the foregoing discussion, we expect that greater IT architecture modularity enhances IT agility, which in turn enhances IT alignment. This leads to our first hypothesis.

HYPOTHESIS 1. *IT agility mediates the positive influence of IT architecture modularity on IT alignment.*

2.3. IT Governance Decentralization

A complementary facet of modularity is organizational modularity. A modular organization structure is one in which decision making is intentionally decentralized among departments (Karim 2006). In the IT function context, this is represented by

[1] This has been observed in practice in a recent McKinsey industry survey, which found that organizations often find it hard to adapt their IT applications to keep up with changing market needs (Marwaha and Willmot 2006).

[2] For example, changes in a tightly coupled shipping application might also require changes to other applications that handle accounting, inventory management, or manufacturing. Application-level changes in less modular architectures might therefore require simultaneous changes in other applications.

Table 1 Variants of the Two Types of Decision Rights in Various Literatures

Type of decision right: What the IT function should accomplish	Type of decision right: How the IT function should accomplish it	Disciplinary home base	Representative reference in parent discipline
Specification decision rights	Implementation decision rights	Information systems	(Kirsch and Beath 1996)
Strategic decision rights	Execution decision rights	Information systems	(Ross et al. 2006)
Specification decision rights	Production decision rights	New product development	(Iyer et al. 2005)
Strategic decision rights	Operational decision rights	Operations	(Vazquez 2004)
Decision control rights	Decision management rights	Management and information systems	(Fama and Jensen 1983, Tiwana 2009)

decentralization of IT governance structure. IT governance decentralization (centralization) refers to the degree to which the line functions (IT function) have *greater* decision-making authority for IT decisions (Brown 1997). Centralization and decentralization represent the two ends of a continuum because IT decision rights are usually shared by the IT and line functions. Fama and Jensen (1983) identify two broad classes of decision rights: (1) those that define *what* objectives a department should accomplish and (2) those that define *how* it should accomplish them. Prior research has used a variety of synonymous labels to describe these two classes of decision rights (see Table 1). For the purpose of this discussion in the IT function context, we label the former as IT specification decision rights and the latter as IT implementation decision rights. *IT specification* decision rights are defined as decision-making authority for specifying what objectives IT should accomplish, and *IT implementation* decision rights specify how it should accomplish those objectives. IT specification therefore encompasses decisions about what business processes in the line functions IT must support, the associated constraints (schedule, budget, quality), objectives, priorities, and performance expectations (e.g., service levels). IT implementation encompasses decisions about the methods, programming languages, platforms, definition of IT standards and policies, and IT sourcing (e.g., outsourcing, purchase, or internal development). IT specification and IT implementation represent distinct but not necessarily covarying dimensions of IT governance. Because some organizations decentralize some IT decisions but centralize others (Brown 1997), decentralization of one class of IT decision rights does not necessarily increase decentralization of the other. We therefore use IT specification and IT implementation decentralization as formative dimensions of IT governance decentralization.[3]

2.3.1. Complementarity Between IT Architecture Modularity and IT Governance Decentralization. Although IT architecture modularity enhances flexibility, its agility-enhancing benefits are amplified when it is complemented by IT governance decentralization. Line functions are usually better attuned to their own operational realities and therefore are better positioned than the IT department to recognize important trends, opportunities, and problems that IT can help them address (Sambamurthy and Zmud 2000). IT governance decentralization empowers them to initiate changes to existing applications or to deploy new applications to address emerging opportunities. However, governance decentralization alone is not enough to enhance IT agility, and it must be complemented by IT modularity. Organizational IT systems are often used by heterogeneous user communities with diverse needs, and require interoperability across constellations of heterogeneous, specialized applications spanning line functions (Star and Ruhleder 1996, Weill and Ross 2005). Thus, initiating a change in one application might require identifying others that interact with or might be affected by it.[4] Individual line functions are less likely to have a holistic understanding of the organization's IT applications portfolio to be able to readily recognize such cross-application interdependencies, and to integrate new/adapted applications with existing applications. Therefore, the advantage

[3] As a robustness check, we subsequently also test two competing conceptualizations: (a) a reflective specification of the second-order construct and (b) retention of the two decentralization dimensions as separate first-order constructs. The results in both cases are identical to the more parsimonious second-order formative conceptualization.

[4] For example, one department's transactions might depend heavily on the availability, accuracy, and timeliness of data from other departments. In their recent industry study, Ross et al. (2006) observed that complex interdependencies required that changes to any major application required individually rewiring it to all other systems to which it connected.

of increased alertness gained through IT governance decentralization can be overwhelmed by an increased need for overt interdepartmental coordination.

However, decentralization of IT governance is less likely to exacerbate interdepartmental coordination challenges when such decentralization works in tandem with modular IT architectures. Because design interfaces drive interactions to coordinate activities across departments (Sosa et al. 2004), modularity reduces interdepartmental dependencies, decreasing the need for overt interdepartmental coordination. In the presence of greater IT architecture modularity, changes to one application in a loosely coupled architecture are less likely to have a ripple effect on other applications or inadvertently sabotage their interoperability. Modular IT architectures also simplify application integration because organization-wide IT standards prespecify how various loosely coupled applications connect, interact, and interoperate. Integration among new or adapted applications in a modular architecture can then be achieved simply by complying with the preexisting standards, which provide an embedded coordination mechanism (Sanchez and Mahoney 1996). A modular IT architecture therefore allows individual line functions to independently define how IT should support their activities and to act on emerging opportunities to deploy enabling IT applications without being constrained by an extensive need for coordination with other line functions. Decentralizing IT governance therefore raises organizational alertness to new IT opportunities at the line function level, and IT architecture modularity lowers the need for interdepartmental coordination in initiating IT changes in response to such opportunities.

Overall, this *combination* of alertness and flexibility gained through governance decentralization and IT architecture modularity, respectively, enhances the speed with which IT applications can be adapted to meet evolving line function needs. The Li & Fung example described earlier illustrates this. The adoption of a modular Web-service based IT architecture facilitates allowing each the 7,500 Li & Fung suppliers greater autonomy over their internal IT applications and databases. Although, decisions about IT applications are highly decentralized, yet IT architecture modularity across the supplier network allows them to seamlessly interoperate even if individual suppliers' applications need to be changed. In summary, the agility-enhancing benefits of increasing application-level autonomy through IT architecture modularity are increased when such flexibility is complemented by increased alertness engendered by IT governance decentralization. We therefore expect that IT governance decentralization will strengthen (i.e., positively moderate) the effect of IT architecture modularity on IT agility, and in turn IT alignment. This leads to the next hypothesis, which represents a mediated-moderation relationship.

Hypothesis 2. *IT governance decentralization enhances IT alignment by strengthening the influence of IT architecture modularity on IT agility.*

3. Methodology

A field survey of 223 organizations was conducted in 2005 to test the model. The sampling frame was a random sample of 1,100 firms drawn from Dun and Bradstreet's directory of executives. The primary respondents were MIS directors. Line function managers' matched-pair assessments of IT alignment were also collected from a subset of 90 organizations in this pool of 223 organizations to test for common methods bias. Prospective respondents were first sent a prenotification letter and then telephoned three weeks later to solicit participation. Managers who could be contacted or reached via voicemail (904) were then retained in the survey sample pool. Three mailings were sent to these management information systems (MIS) directors, generating 223 usable responses. This represents a response rate of 24.6% (223/904). The response rate for the matched-pair respondent in the follow-up phase was 40.3% ($N = 90$). The majority of these were marketing/sales and operations managers, whom our preliminary interviews suggest were appropriate informants about their IT function's alignment. The participating organizations represented a variety of industries including industrial products, engineering, manufacturing, services, construction, and telecommunications. The average age of the IT unit in the responding organizations was 14.6 years (SD 8.12 years) and the average IT experience of the responding MIS directors was 16.47 years (SD 9.3 years). The average revenue of the responding organizations in the study was \$31 million (SD \$49.9 million) and employed 173 individuals (SD 151). T-tests on the independent variables (IT specification decentralization, $T = 1.48$; IT implementation decentralization, $T = 0.85$; architecture modularity, $T = 0.83$) and organizational characteristics (firm size, $T = 0.092$; CIO on board, $T = 1.18$; IT intensity, $T = 0.41$; IT unit size, $T = 0.43$) comparing early (first 50) and late (last 50) respondents indicated that nonresponse bias was not a pervasive threat.

3.1. Construct Operationalization and Scale Development

All key constructs in the model were measured using multi-item, 7-point Likert scales. New scales were developed for IT architecture modularity and IT governance decentralization. Measures for IT agility and alignment were adapted from the literature, and existing scales were used for the control variables. The scale items are summarized in the appendix and Table 2 provides an overview of the main constructs.

The descriptions of technical and organizational modularity in the extant literature were used as a starting point for scale development (see Table 2). Preliminary item pools in the IT context were generated based on a review of the literature and subsequently refined through a series of interviews with a convenience sample of nine IT managers and five academic experts. The objective of this refinement process was to ensure that the scale items were meaningful in an IT function context and unambiguously captured the domain of each construct. Several items were eventually deleted (indicated by $*$ in the appendix), resulting in scales that reliably captured the underlying construct.

IT architecture modularity was measured as a second-order construct consisting of two formative dimensions identified in the modularity literature (Sanchez and Mahoney 1996): IT architecture loose coupling and organizationwide IT standardization. The formative conceptualization of this construct was based on the logic that increases in architecture loose coupling and IT standardization increase IT architecture modularity, but they do not necessarily covary. Nambisan's (2002) software modularity scale was used as the starting point for developing this scale. IT *architecture loose coupling* was measured using four items that assessed the degree of interdependencies, interoperability, and plug-and-play relationships among the IT applications used in the organization. IT *standardization* was measured using five items that assessed the extent to which organizationwide IT standards, policies, architecture, and compliance guidelines for IT applications were clearly established. *IT governance decentralization* was measured as a second-order construct consisting of two formative dimensions: IT specification decentralization and IT implementation decentralization. *IT*

Table 2 Summary of the Key Constructs and Their Measures

Construct	Definition	No. of items	Role in nomology	Representative references guiding our conceptualization
IT architecture modularity	The degree of decomposition of an organization's IT portfolio into loosely coupled subsystems that communicate through standardized interfaces.	9	Antecedent	(Nambisan 2002, Parnas 1972, Sanchez and Mahoney 1996, Sosa et al. 2004, Star and Ruhleder 1996, Zweben et al. 1995)
IT governance decentralization	The degree to which IT specification and IT implementation decisions are made by the line functions vis-à-vis the IT department. IT specification decisions pertain to what business processes in the line functions IT must support, the associated constraints (schedule, budget, quality), objectives, priorities, and performance expectations (e.g., service levels). IT implementation decisions pertain to the methods, programming languages, platforms, definition of IT standards and policies, and IT sourcing.	10	Moderator	(Brown 1997, Ross et al. 2006, Tiwana 2008, Weill and Ross 2005)
IT agility	The capacity of the IT function to rapidly adapt to changing line function demands and opportunities.	6	Mediator	(Prahalad and Krishnan 2002, Sambamurthy et al. 2003)
IT alignment	The degree to which the IT function supports the goals and priorities of an organization's line functions.	6	Dependent variable	(Hirschheim and Sabherwal 2001, Reich and Benbasat 2000, Sabherwal et al. 2001, Tiwana et al. 2003)

specification decentralization was measured using five items that assessed the extent to which the primary responsibility for identifying IT investment opportunities, establishing IT performance metrics, defining IT service level expectations, and setting budgets and timelines for IT initiatives resided to a greater degree with the line functions vis-à-vis IT. *IT implementation decentralization* was measured using five items that assessed the extent to which the primary responsibility for decisions about application platforms, programming languages and tools, IT sourcing decisions (e.g., purchasing, outsourcing, or in-house development), defining IT standards and policies, and defining IT standards and policies initiatives resided to a greater degree with the line functions vis-à-vis IT. *IT alignment* was measured using a six-item adaptation of the Tiwana et al. (2003) scale that assessed the degree to which the work produced by the IT function was well aligned with the line functions' activities, expectations, needs, demands, priorities, and business objectives. *IT agility* was measured using six items that assessed the extent to which the IT function, in the work that it produced for the line functions, was agile, adaptive, flexible, able to improvise, responsive to changing line function needs and priorities, and responsive to a wide range of contingencies (Sambamurthy et al. 2003). The items and sources for the controls appear in the appendix.

4. Analysis and Results

Partial least squares (PLS)—a second-generation structural equation modeling technique—was used to assess the measurement model and then to test the hypothesized structural model.[5]

4.1. Measurement Model Assessment

The first step in the model assessment is to evaluate the psychometric adequacy of the measurement model. Interconstruct correlations, scale Alphas, means, and standard deviations are summarized in Table 3.

The acceptable scale Alphas (≥ 0.74) and eigen values (>1) for all constructs provide the first assurance that the scales had high convergent validity. The loadings of all indicators on the corresponding theoretical constructs also exceeded the recommended 0.7 threshold in the PLS measurement model. Discriminant validity was confirmed by four assessments in the PLS measurement model: (1) items had low (<0.5) and nonsignificant cross loadings, (2) the diagonal elements representing the square root of average variance extracted exceeded the off-diagonal elements in the construct correlation matrix (see Table 3), (3) the ratio of the variance in the indicators for each construct relative to the total amount of variance exceeded 0.5, and (4) the item cross loadings across constructs were low relative to loadings on the focal construct. The exploratory factor analysis matrix in the appendix provides further support for discriminant validity. Next, we assessed whether the first-order indicators of IT architecture modularity and IT governance decentralization reliably measured them as second-order constructs. This is indicated by the existence of a statistically significant path coefficient between the first-order dimensions of each second-order construct, which represents the weights in the case of formative constructs. For IT architecture modularity, the weights of IT architecture loose coupling ($\beta = 0.50$, T-value $= 2.94$, $p < 0.01$) and IT standardization ($\beta = 0.69$, T-value $= 4.54$, $p < 0.001$) were high and statistically significant. Similarly, for IT governance decentralization, the weights of IT specification decentralization ($\beta = 0.42$, T-value $= 2.13$, $p < 0.05$) and IT implementation decentralization ($\beta = 0.91$, T-value $= 9.80$, $p < 0.001$) were high and statistically significant. (As a robustness check, we also reestimated the model with modularity and governance decentralization conceptualized reflectively; the results were consistent with the formative models.) Overall, this suggests psychometric adequacy of the measurement model.

4.2. Structural Model Assessment

The hypothesized PLS structural model represents a *mediated-moderation* model (Muller et al. 2005) (also labeled as first-stage moderation by Edwards and Lambert 2007). Mediated moderation means that the

[5] The choice of PLS was motivated by three considerations. First, the second-order constructs in the model were formative, which cannot be modeled using covariance-based structural equation modeling approaches such as LISREL. Second, like LISREL, PLS allows the simultaneous assessment of multiple dependent variables and test statistical mediation. Third, several constructs used newly developed scales. PLS' ability to assess the measurement model within the context of its theoretical mediated model makes it superior to multiple regression and traditional path-analytic techniques.

Table 3 Construct Correlations and Distributions

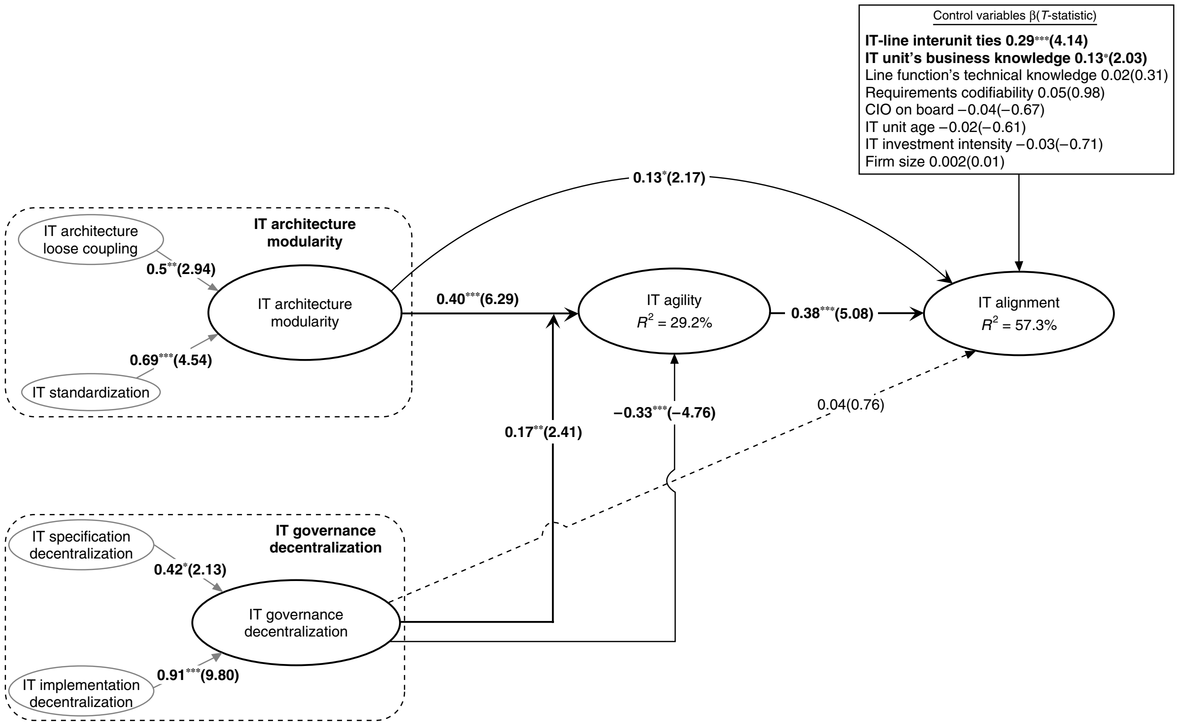
Construct	Mean	SD	Alpha	No. of items	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. IT standardization	4.76	1.25	0.9	5	**0.85**													
2. IT architecture loose coupling	4.39	1.01	0.74	4	0.398**	**75**												
3. IT specification decentralization	3.73	1.52	0.91	5	0.045	0.03	**0.85**											
4. IT implementation decentralization	2.00	0.95	0.82	5	−0.018	0.054	−0.002	**0.77**										
5. IT agility	5.42	0.97	0.93	6	0.301**	0.355**	−0.175**	0.014	**0.87**									
6. IT alignment	5.32	0.9	0.92	6	0.327**	0.353**	−0.053	0.021	0.655**	**0.84**								
7. IT-line interunit ties	5.19	0.67	0.91	3	0.004	0.051	−0.019	−0.095	0.042	0.074	—							
8. IT unit's business knowledge	4.91	1.09	0.93	5	0.024	−0.058	0.018	−0.239**	0.004	0.034	0.263**	**0.89**						
9. Line functions' technical knowledge	2.89	1	0.91	6	−0.034	−0.06	−0.066	0.154*	0.07	−0.01	0.071	0.128	**0.83**					
10. Requirements codifiability	4.52	1.12	0.86	4	0.013	−0.062	−0.006	−0.093	0.003	0.011	0.180**	0.279**	0.136*	**0.84**				
11. CIO on board	—	—	—	1	0.075	0.09	0.052	−0.118	0.038	0.051	−0.059	0.001	0.146*	−0.095	—			
12. IT unit age	14.7	6.81	—	1	−0.076	−0.098	0.042	−0.055	−0.029	−0.012	0.119	0.009	0.127	0.107	−0.121	—		
13. IT investment intensity	3.15	1.45	—	1	0.023	−0.027	−0.024	−0.116	0.02	0.065	0.044	0.057	0.232**	0.039	0.031	−0.051	—	
14. Firm size	173	114.68	—	1	0.012	0.05	−0.146*	−0.033	0.031	0.023	0.001	0.02	−0.016	−0.025	0.04	0.041	−0.041	—

*$p < 0.05$; **$p < 0.01$; bold diagonals represent the square root of average variance extracted for multi-item scales; product term is standardized; $N = 223$.

interaction between the predictor and the moderator influences the dependent variable through a mediator (Edwards and Lambert 2007). Because our model proposes that the relationship between IT architecture modularity (the predictor) and IT agility (the mediator) is moderated by IT governance decentralization (the moderator), and that IT agility in turn influences IT alignment (the dependent variable), it denotes mediated moderation. A contrasting model that also integrates moderation and mediation is the moderated-mediation model where the mediation effect itself is contingent on the moderator. Theorizing moderated mediation would instead imply that whether IT agility serves as a mediator in our nomological network is contingent on the degree of IT governance decentralization. We therefore followed the guidelines for assessing mediated moderation outlined by Muller et al. (2005) and Edwards and Lambert (2007). A bootstrapping procedure with replacement using 1,000 subsamples was used to estimate the statistical significance of the parameter estimates. The bootstrapping procedure eliminates the need to assume normality and is strongly recommended for models that combine mediation and moderation (Edwards and Lambert 2007). Figure 2 summarizes the results of the structural model assessment corresponding to the stepwise mediated moderation analyses described next.

To test the first hypothesis, which proposed that the effect of IT architecture modularity on IT alignment is *mediated* by IT agility, we followed the mediation testing procedure suggested by Edwards and Lambert (2007). IT agility had a significant, positive relationship with IT alignment ($\beta = 0.384$, T-value $=$ 5.08, $p < 0.001$), and IT architecture modularity had a significant, positive relationship with IT agility ($\beta = 0.399$, T-value $= 6.29$, $p < 0.001$). The Sobel mediation test statistic had a significant value of 3.95 ($p < 0.001$), providing evidence that IT agility significantly mediates the relationship. Variants of the Sobel test also yielded significant mediation statistics (e.g., Aroian test statistic: 3.92, $p < 0.001$; Goodman test: 3.98, $p < 0.001$). Hypothesis 1 is therefore supported. We also observed a smaller direct effect from modularity to IT alignment ($\beta = 0.125$, T-value $= 2.17$, $p < 0.05$), suggesting that the relationship is partially mediated (see Edwards and Lambert 2007).

Figure 2 Results

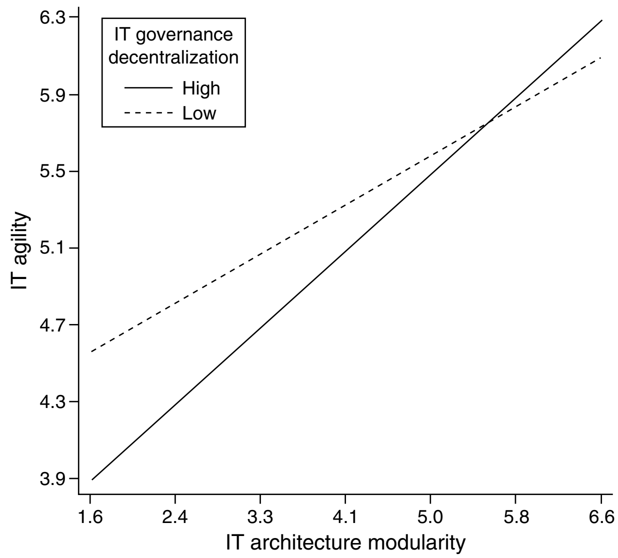


Notes. 1. The numbers in the path model represent β (*T*-value); $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$; $N = 223$ organizations. 2. Solid hypothesized paths are significant; dotted path is nonsignificant; unhypothesized paths (nonbold) are shown for model completeness; dimensions of second-order constructs are shown in a lighter gray shade.

Testing *mediated moderation* proposed in the second hypothesis requires demonstrating that IT agility mediates the effect of the positive interaction between IT architecture modularity and IT governance decentralization on IT alignment. This requires a multistep procedure (see Edwards and Lambert 2007) to show—in addition to a significant relationship between IT alignment and IT agility—that: (a) the effect of IT modularity on IT agility is significantly moderated by IT decentralization, (b) the effect of this moderating term on IT alignment is significantly mediated by IT agility, and (c) the direct effect of the moderator on the mediator decreases in magnitude in the presence of the interaction term. We first added the main effect of IT governance decentralization to the preceding model. The main effect was significant and negative ($\beta = -0.327$, *T*-value $= -4.76$, $p < 0.001$).[6] We then added an interaction term between IT architecture modularity and IT governance decentralization, which we created using the standardized product-indicator approach of Chin et al. (2003). This required creating four standardized product terms between the averaged score for each of the two first-order indicators of IT architecture modularity and IT governance decentralization, which were then used as the four indicators of the interaction effect term. The interaction effect had a positive and significant relationship with IT agility ($\beta = 0.17$, *T*-value $= 2.41$, $p < 0.01$). A mediation test (Sobel test statistic 2.18, $p < 0.05$) further confirmed that IT agility significantly mediates the effect of the interaction term on IT alignment. Adding the interaction term also decreased the magnitude of the simple effect (i.e., the direct effect coefficient in the presence of the interaction term) of the moderator on the mediator ($\beta = -0.302$, *T*-value $= -4.53$, $p < 0.001$). Adding the moderator increased the R^2 for IT agility from 15.9% to 29.2% (*F*-change 11.35; $p < 0.001$), suggesting that it contributes additional

[6] Furthermore, the effect of IT governance decentralization on IT alignment was fully mediated by IT agility (Sobel test statistic 3.47, $p < 0.001$), and it had no direct effect on IT alignment ($\beta = 0.043$, *T*-value $= 0.76$, ns).

Figure 3 Interaction Plots for High (+2 SD) and Low (−2 SD) IT Governance Decentralization



explanatory power to the model. Thus, all aforementioned conditions for mediated moderation were met, supporting Hypothesis 2.[7]

Figure 3 illustrates this interaction effect. High and low lines in the interaction plot represent ±2 standard deviations from the mean value of IT governance decentralization. The interpretation of interaction effects plots relies on comparing the slope (rather than absolute values) of the relationship between the predictor and the dependent variable for varying levels of the moderator (Edwards and Lambert 2007, p. 16). The steeper slope of the solid line compared to the dotted line illustrates that an increase in IT architecture modularity is associated with a larger (smaller) increase in IT agility when IT governance decentralization is high (low).

Assessment of Rival Explanations. To account for rival explanations of IT alignment, eight control variables were included in the model. Stronger IT—line function ties, defined as the frequency and closeness of interaction between IT and line functions, can enhance IT alignment (Reich and Benbasat 2000). Second, greater depth of knowledge that IT and line functions have of the other's domain (i.e., business knowledge in the IT function and technical knowledge in the line functions) increases IT performance by easing coordination between them (Reich and Benbasat 2000). Third, the greater the extent to which line functions' IT requirements can be readily be codified for the IT function, the greater the likelihood of fulfilling them. Additional control variables included a dummy-coded variable for the presence of the CIO or equivalent on the board, the age of the IT function, IT investment intensity (percentage of revenue spent on IT), and firm size. The significant controls are shown in bold in the results in Figure 2. The model explained 57.3% of the variance in IT alignment, of which the controls explained 31.8%.

4.2.1. Assessment of the Common Methods Bias Threat. We conducted four types of analyses to assess the threat of common methods bias: (1) *Harman's one-factor test*, (2) Lindell and Whitney's (2001) *marker variable test*, (3) triangulation using *interrater agreement* among IT and line function managers for the matched-pair subset of the data, and (4) *model retest with matched-pair data* subset. First, we conducted Harman's one-factor test, where the emergence of a single factor that accounts for a large proportion of the variance in factor analyses suggests a common methods bias. However, no such single factor emerged on entering all independent, mediating, and dependent variables in an exploratory factor analysis (see Table A.1), and the first factor accounted for 9.35% of the 73.4% explained variance. Second, the marker variable technique uses a theoretically unrelated variable (the *marker* variable) to adjust the correlations among the principal constructs in the model (Lindell and Whitney 2001). Any high correlation of the marker variable with any of the study's principal constructs would indicate common methods bias. Because a marker variable is unrelated to the study's principal constructs, the correlations should be close to zero. For robustness, we separately repeated the marker variable test with two variables that are not included in the model (IT department size and publicly traded firm dummy) and one that is included (IT department age) for which we have little or no theoretical basis to expect a relationship with

[7] As additional robustness checks, we also retested the model: (a) using a reflective specification of IT governance decentralization and (b) disaggregating the underlying dimensions of IT governance decentralization. These tests yielded patterns of relationships consistent with our more parsimonious second-order formative specification.

the study's principal constructs. The average correlation between the study's principal constructs for IT size ($r = 0.063$, $T = 0.64$), public dummy ($r = 0.15$, $T = 1.26$), and IT age ($r = 0.065$, $T = 0.716$) was low and nonsignificant, providing no evidence of common methods bias. Third, we statistically triangulated IT alignment (the dependent variable) responses of IT managers with those from line function managers. Because our attempt to create a matched-pair sample from client managers yielded only a 40.35% response rate ($N = 90$), the line function respondent could not exclusively be used directly in the structural model analysis. However, this limited subsample was large enough to assess line and IT managers' interrater agreement. We found a strong and statistically significant correlation in their assessments of IT alignment ($\beta = 0.567$; T-statistic 6.38; $p < 0.001$). The IT and line managers therefore exhibited statistically significant agreement in their responses. Furthermore, T-tests revealed no significant differences between the characteristics of the organizations that did and did not provide matched-pair responses (size, $T = 0.61$; CIO on board, $T = 0.55$; IT size, $T = 0.57$; IT intensity, $T = 0.39$; all nonsignificant). Finally, retests using *matched-pair* and line-IT averaged data from only the subsample of 90 organizations for which we had assessments from both line function and IT function managers revealed significant paths consistent with the full-sample ($N = 223$) analyses. Collectively, these results reveal no evidence of common methods bias.

5. Discussion and Implications

5.1. Contributions and Implications for Research

Our distinctive theoretical emphasis was on how the interplay of organizational IT architecture with IT governance structure influences IT alignment. We built on modular systems theory to develop two ideas: (1) IT architecture modularity enhances IT alignment by increasing IT agility (the mediator in our nomology) and (2) IT governance decentralization complements IT architecture modularity, i.e., increasing one increases the benefits of increasing the other. Empirical support for these ideas represents two distinctive theoretical contributions.

Our first contribution is an explanation of *how* IT architecture modularity enhances IT alignment. Our results show that IT agility is an important intervening variable that mediates the positive effect of IT architecture modularity on IT alignment (Hypothesis 1; mediation). This implies that increasing modularity increases IT alignment *because* it fosters greater IT agility. This finding represents a novel contribution to both the IT governance literature and the broader modularity literature.

Although IT modularity is implicitly assumed in the enterprise information systems literature, this is the first study to explicitly conceptualize the underlying architectural modularity construct and to theorize how it influences IT alignment. Paradoxically, this finding implies that rigidity in IT architectures (e.g., enforcing standardization to increase modularity) increases IT agility. This observation squares nicely with Star and Ruhleder's (1996) idea that developing flexibility at a higher level requires building in rigidity at a lower level. From a theory development perspective, this emphasizes that enforcing discipline in organizational IT architectures and standardizing application interfaces that appear to decrease the line functions' autonomy over their IT investments is necessary to foster an agile IT platform that supports and enables business moves throughout the organization.

In the broader modularity literature, although Sanchez and Mahoney (1996) suggest that modularity lowers the time and cost of adaptation, mediating mechanisms such as agility have not been incorporated in subsequent empirical or simulation studies (Ethiraj and Levinthal 2004, Karim 2006, Tiwana 2008). Our mediation finding contributes evidence for this untested adaptation centric proposition regarding technological modularity. However, this relationship was partially mediated, implying that architectural modularity also enhances IT alignment through mechanisms other than enhancing IT agility. For example, organizations with highly modular architectures might be able to decompose larger projects into incremental subprojects (Hagel 2002) and more readily integrate off-the-shelf applications or modular open source software components.

Our second, more distinctive, contribution regards the complementarity between IT architecture modularity and IT governance decentralization, and how this complementarity enhances IT alignment (Hypothesis 2; mediated moderation). This finding contributes a novel perspective on how harmony between the technical and organizational design of the IT function enhances IT alignment. Although decentralized IT governance gives plausibly better-informed line functions greater autonomy over IT decisions, this autonomy translates into enhanced agility only when it works in tandem with IT architecture modularity. In other words, there exist previously underappreciated interactions between technological and organizational IT function design choices.

This represents a contribution to the IT governance literature, which recognizes that IT governance structure predicts IT alignment but has not theoretically explored its interaction with the design of organizational IT architectures. Although organizations can increase alertness to line functions' needs by decentralizing IT governance, the exacerbated need for overt interdepartmental coordination can overwhelm its advantages. The significant, negative main effect from IT governance decentralization to IT agility supports this assertion. The observed positive interaction effect implies that the agility-enhancing benefits realized from increasing architectural modularity are amplified by decentralization of IT governance. The appropriateness of IT centralization/decentralization choices is therefore contingent on their consonance with organizational IT architecture. Further, the effect of IT governance decentralization on IT alignment was fully mediated by IT agility, suggesting its role as a theoretical explanation for *how* IT governance choices translate into enhanced IT alignment. Collectively, these findings directly extend the fledgling research literature on IT agility (Sambamurthy et al. 2003), which has previously not explored its antecedents and consequences.

Our second finding also contributes to the broader modularity literature, which has both asserted and questioned, but not directly examined, complementarities between technological and organizational modularity. Because IT governance decentralization and IT architecture modularity, respectively, represent organizational and technological facets of modularity, our results imply that they are indeed complements. This result offers direct evidence for Sanchez and Mahoney's (1996) untested assertion that fully realizing the advantages of technological modularity also requires modularity in the associated organizational structures. The mediating role of IT agility extends the idea that there ought to be "fit" between technological and organizational modularity (e.g., Sosa et al. 2004), to which we add an explanation for *how* such fit improves alignment. This finding therefore complements and theoretically extends recent theory-testing studies of modularity at the individual project level (e.g., Tiwana 2008) to the organizational/enterprisewide IT platform level. In particular, we significantly extend the theoretical development of the recent, broader idea in the strategy literature that modularity decreases the need for control (see Tiwana 2008). In a broader organization theory context, these results confirm Siggelkow and Rivkin's (2006) assertion that decentralization is appropriate when decisions and departments are modularized.[8]

5.2. Limitations

Three limitations of the study merit consideration. First, our cross-sectional data can only ascertain association, not causal ordering. Second, firms in the study were relatively small, raising concern about whether the results generalize to larger firms. To assess how firm size might limit generalizability, we conducted a post hoc test of the relationship between firm size and all principal constructs in the study. This allowed us to assess whether and how this biased our results. We found no statistically significant relationship between firm size and IT agility (T-statistic 1.59), IT alignment (T-statistic 0.79), line technical knowledge (T-statistic 0.17), IT unit's business knowledge (T-statistic -0.24), IT specification decentralization (T-statistic -0.34), IT implementation decentralization (T-statistic -0.002), IT architecture loose coupling (T-statistic -0.84), or IT standardization (T-statistic -0.36; all nonsignificant). This analysis suggests that the average firm size in our sample does not systematically bias the results. Third, although we did not control for industry, it is less likely to affect the results because Brown (1997) has shown that industry is not a strong predictor of IT organizational structure.

[8] They showed in a *simulation* that although decentralization by itself diminishes organizational performance, it enhances it when organizational departments are loosely connected and their interdependencies are low.

5.3. Implications for Practice

Our results have three implications for practice. First, managers should view IT alignment as a dynamic, ongoing process of correcting emergent misfits between IT activities and evolving business needs. Second, they should recognize that the adoption of modular IT architectures such as SOA and Web services contributes to sustained IT alignment primarily by facilitating agility in organizational IT activities. If the need for such agility is low in their industry, such investments are less likely to contribute to IT alignment. Third, they must view IT architecture and IT governance design as a system of interdependent choices. Inattention to the design of IT architectures can erode the potential advantages of IT governance decentralization. The benefits of decentralized IT governance can only be realized when it is consonant with the organizational IT architecture. Careful thought to ensuring correspondence between IT architecture and IT governance design choices can allow their organizations to remain better attuned to line functions' IT needs.

5.4. Directions for Future Research

Future research can extend these findings in five promising directions. First, future studies should use temporally ordered longitudinal data to assess whether modularization of IT architectures leads to greater IT decentralization or vice versa. Second, to what extent does the IT function require business knowledge and the line functions require technical knowledge to modularize IT architectures? The notion of *peripheral knowledge* (Tiwana and Keil 2007)—defined as knowledge outside a department's specialized domain—can provide a viable anchor for theory development. Such knowledge contradicts the notion of departmental specialization, yet has been shown to facilitate outcome (but not process) control in interfirm IT alliances. These ideas might also extend to intrafirm settings in such a theory development endeavor. Third, how should the responsibility for IT architecture modularization be partitioned between the IT and line functions? The notion of classes of decision rights (see Table 1) and the knowledge associated with them can provide a starting point for conceptual development. Fourth, this study focused on IT alignment as the dependent variable, but the link between our model and IT function performance is still not established and awaits future work. Finally, although governance decentralization *by itself* has a negative relationship with IT agility, it might be positively related to other organizational outcomes, which should be explored in future research.

Overall, this work represents an initial step in understanding how organizations can use modular systems thinking to foster sustainable IT alignment. More broadly, the study advocates a shift in the debate to when and how—rather than whether—IT decentralization enhances IT agility and alignment.

Acknowledgments

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Appendix: Measures

The respondents were instructed that the term IT unit referred to their organization's IT department and line functions referred to the various departments in their organization, such as sales, purchasing, manufacturing, human resources, and accounting. Enterprise-wide IT was defined as the portfolio of IT applications and infrastructure used in all of their organization's line functions taken together. All multi-item scales used 7-point measures. (* indicates dropped items.)

IT architecture modularity was measured as a second-order formative construct with two underlying dimensions: IT architecture loose coupling and IT standardization. (The model was also robust in an alternative reflective specification.) *IT architecture loose coupling* was assessed using four items that tapped into the extent to which the following characteristics described the overall relationships among the departmental components (e.g., departmental IT infrastructure and applications) of the firm's enterprise IT architecture: (1) plug-and-play, (2) highly interoperable, (3) well-understood interdependencies, (4) minimal unnecessary interdependencies, (5) loosely coupled*, and (6) highly modular*. The scale anchors were 1: Strongly disagree—7: Strongly agree. Four items were retained after scale purification. IT *standardization* was assessed using six items that measured the extent to which the following aspects of IT were well established at the enterprisewide level: (1) IT standards, (2) IT policies, (3) IT architecture, (4) compliance guidelines for line function IT applications, (5) compliance guidelines for line function IT infrastructure, and (6) dedicated IT liaisons for each line function*. Five items were retained after scale purification. The scale anchors were 1: Very poorly established—7: Very well established.

Table A.1 Exploratory Factor Analysis

	Factor									
Item	1	2	3	4	5	6	7	8	9	10
IT agility2	**0.83**	−0.02	0.12	0.23	−0.10	0.03	−0.11	0.13	0.13	0.10
IT agility1	**0.76**	−0.03	0.17	0.21	−0.07	0.02	−0.11	0.19	0.10	0.04
IT agility4	**0.76**	0.00	0.15	0.20	−0.11	0.13	−0.15	0.02	0.06	0.16
IT agility5	**0.75**	0.02	0.15	0.25	−0.02	0.14	−0.14	0.09	0.09	0.11
IT agility3	**0.75**	−0.02	0.13	0.29	−0.14	0.01	−0.04	0.12	0.12	0.07
IT agility6	**0.70**	−0.04	0.16	0.24	−0.04	0.18	−0.12	0.05	0.14	0.10
Line functions' technical knowledge2	0.02	**0.86**	0.05	0.08	0.06	0.12	0.10	0.01	0.14	−0.04
Line functions' technical knowledge4	0.00	**0.84**	0.02	0.04	−0.06	0.15	0.11	0.00	0.03	0.05
Line functions' technical knowledge3	0.04	**0.82**	−0.04	0.06	0.00	0.15	0.05	−0.08	0.07	0.04
Line functions' technical knowledge7	−0.01	**0.79**	0.06	−0.01	−0.03	0.12	0.07	0.08	−0.02	0.08
Line functions' technical knowledge1	−0.07	**0.78**	0.04	0.05	0.08	0.11	0.02	0.02	0.11	−0.07
Line functions' technical knowledge6	−0.03	**0.77**	0.11	−0.07	−0.03	0.18	0.04	0.17	0.07	0.05
IT unit's business knowledge5	0.09	0.07	**0.86**	0.19	−0.06	0.07	−0.04	0.10	0.12	0.13
IT unit's business knowledge3	0.10	0.10	**0.85**	0.23	−0.03	0.14	−0.14	0.06	0.11	0.08
IT unit's business knowledge2	0.20	0.07	**0.83**	0.16	−0.11	0.13	−0.07	−0.01	0.06	0.07
IT unit's business knowledge4	0.11	0.03	**0.82**	0.20	−0.03	−0.01	−0.05	0.12	0.06	0.19
IT unit's business knowledge1	0.27	−0.02	**0.80**	0.09	−0.13	0.10	−0.10	0.13	0.00	0.05
IT alignment5	0.17	0.05	0.15	**0.80**	0.04	0.07	−0.10	0.09	0.07	0.03
IT alignment2	0.18	0.03	0.13	**0.76**	−0.02	0.14	−0.03	0.09	0.14	0.12
IT alignment3	0.29	−0.02	0.20	**0.76**	−0.04	0.07	−0.10	0.08	0.12	0.14
IT alignment4	0.29	0.05	0.17	**0.72**	0.03	0.08	0.00	0.14	0.06	0.08
IT alignment6	0.35	0.11	0.25	**0.64**	−0.04	0.12	−0.03	0.11	0.04	0.21
IT alignment1	0.43	0.01	0.23	**0.62**	−0.01	0.08	−0.04	0.13	0.15	0.19
IT specification decentralization1	−0.02	0.02	−0.10	0.04	**0.88**	0.05	−0.06	−0.01	0.01	−0.04
IT specification decentralization2	−0.11	−0.09	−0.03	0.04	**0.87**	0.06	−0.01	0.08	0.01	0.02
IT specification decentralization3	−0.10	0.02	−0.05	−0.01	**0.86**	0.01	0.06	0.02	0.00	0.05
IT specification decentralization4	−0.10	0.00	−0.09	0.00	**0.86**	0.01	−0.04	−0.02	0.04	−0.08
IT specification decentralization5	0.00	0.07	−0.02	−0.07	**0.78**	0.00	0.00	−0.07	0.04	0.06
IT standardization2	0.08	0.22	0.10	0.09	0.01	**0.82**	−0.08	0.09	0.07	0.11
IT standardization4	0.05	0.18	0.14	0.11	0.07	**0.78**	0.00	0.17	0.07	−0.10
IT standardization5	0.06	0.20	0.07	0.10	0.11	**0.78**	−0.06	0.12	0.16	−0.09
IT standardization1	0.09	0.24	0.10	0.09	0.01	**0.78**	−0.13	0.05	0.15	0.06
IT standardization3	0.18	0.17	−0.01	0.06	−0.03	**0.69**	−0.30	−0.01	0.15	0.14
IT implementation decentralization9	−0.12	0.12	0.03	−0.14	0.05	−0.14	**0.85**	−0.02	0.05	0.01
IT implementation decentralization8	0.00	0.03	0.02	−0.10	0.08	−0.09	**0.82**	−0.13	0.07	−0.01
IT implementation decentralization6	−0.03	0.10	−0.14	−0.09	−0.07	−0.12	**0.70**	0.09	−0.08	0.16
IT implementation decentralization3	−0.17	0.08	−0.16	0.13	−0.16	0.02	**0.67**	0.04	−0.08	−0.08
IT implementation decentralization4	−0.30	0.11	−0.18	0.00	−0.01	−0.07	**0.64**	−0.06	−0.02	−0.25
Requirements codifiability2	0.06	0.04	0.10	0.14	−0.06	0.05	−0.02	**0.86**	0.16	0.17
Requirements codifiability3	0.06	0.03	0.11	0.13	−0.03	0.05	−0.09	**0.85**	0.18	0.18
Requirements codifiability1	0.13	−0.03	0.13	0.08	0.00	0.18	0.01	**0.81**	−0.01	0.08
Requirements codifiability4	0.22	0.18	0.02	0.11	0.08	0.09	0.00	**0.66**	0.00	−0.10
IT architecture loose coupling3	0.23	0.07	0.14	0.15	−0.06	0.09	−0.02	0.02	**0.73**	0.14
IT architecture loose coupling6	0.10	0.15	0.01	0.11	0.10	0.08	0.01	0.03	**0.73**	−0.03
IT architecture loose coupling5	0.14	0.19	0.11	0.07	0.04	0.25	−0.09	0.06	**0.69**	0.13
IT architecture loose coupling2	0.04	0.02	0.07	0.08	0.00	0.14	0.08	0.27	**0.63**	−0.27
IT-line interunit ties2	0.24	0.05	0.26	0.31	0.01	0.04	0.00	0.20	0.01	**0.73**
IT-line interunit ties1	0.35	0.07	0.28	0.28	−0.02	0.02	−0.11	0.15	0.03	**0.69**
IT-line interunit ties3	0.23	0.08	0.33	0.37	0.05	0.07	0.02	0.16	0.01	**0.63**
Eigen value	**4.96**	**4.38**	**4.31**	**4.25**	**3.83**	**3.57**	**3.13**	**3.08**	**2.32**	**2.08**
Percentage of variance explained (%)	**9.35**	**8.27**	**8.14**	**8.01**	**7.23**	**6.74**	**5.90**	**5.82**	**4.37**	**3.92**

IT governance decentralization was measured as a second-order formative construct with two underlying dimensions: IT specification decentralization and IT implementation decentralization. (The model was also robust in an alternative reflective specification.) *IT specification decentralization* was assessed using five retained items that tapped into how the primary responsibility for the following IT decisions was distributed between the IT and line functions: (1) defining role of IT in line function activities*, (2) identifying new ways in which line functions can leverage IT*, (3) identifying IT investment opportunities, (4) establishing line function IT priorities*, (5) establishing line function IT objectives*, (6) establishing IT performance metrics, (7) defining IT service level expectations (e.g., service level agreements), (8) setting timelines for IT initiatives, and (9) setting budgets for IT initiatives. *IT implementation decentralization* was assessed using nine items that tapped into how the primary responsibility for how the following IT activities be performed was distributed between the IT and line functions: (1) applications development*, (2) systems integration and testing*, (3) choosing application platforms, (4) choosing programming languages and tools, (5) evaluating proposed IT initiatives (e.g., new applications and infrastructure upgrades)*, (6) IT sourcing decisions (e.g, purchasing, outsourcing, or in-house development), (7) vendor qualification/screening*, (8) defining IT standards and policies, (9) defining an IT infrastructure strategy. Five items were retained in each scale after empirical scale purification. The scale anchors were 7: primarily the line functions; 4: shared equally between IT unit and line functions; 1: primarily the IT unit.

IT alignment was measured using six items that asked the respondent for an overall assessment of the extent to which the work that the IT function produced for the various line functions was well aligned with the line functions': (1) activities, (2) expectations, (3) needs, (4) demands, (5) priorities, and (6) business objectives. 1: Strongly disagree—7: Strongly agree.

IT agility was measured using six items that asked the respondent for an assessment of the extent to which the IT function, in the work that it produced for the line functions, was: (1) agile, (2) adaptive, (3) flexible, (4) able to improvise, (5) responsive to changing line function needs and priorities, and (6) responsive to a wide range of contingencies. The scale anchors were 1: Strongly disagree—7: Strongly agree.

IT-line interunit ties was measured by adapting Hansen's (2002) three-item scale, which assessed the degree to which the overall working relationships between IT and line functions were characterized by: (1) regular interactions, (2) frequent communications, and (3) close working relationships. The scale anchors were 1: Strongly disagree—7: Strongly agree.

IT unit's business knowledge was measured using Tiwana's (2003) five item measure that tapped into the overall extent to which members of the IT unit understood the following aspects of their organization's line functions: (1) their unique norms, (2) their unique business goals, (3) their unique business processes, (4) their day-to-day work practices, and (5) their unique business rules and policies. The scale anchors were 1: Not at all; 4: Somewhat; 7: To a great extent.

Line functions' technical knowledge was measured using Tiwana's (2003) six-item measure that tapped into the overall understanding of the members of line functions about the following: (1) IT architectures, (2) systems integration, (3) IT implementation processes, (4) technical feasibility constraints, (5) IT infrastructure technologies (e.g., networks, servers, e-mail, Intranets), and (6) IT infrastructure management (e.g., maintenance and upgrades). The scale anchors were 1: Not at all; 4: Somewhat; 7: To a great extent.

Requirements codifiability was measured by adapting Hansen's (2002) four-item noncodification scale that tapped into the extent to which the IT needs and requirements of the various line functions could be: (1) easily documented, (2) easily explained to the IT unit, (3) easily conveyed to the IT unit, and (4) conveyed formally (e.g., through documents, reports, requirements, and manuals). The scale anchors were 1: Not at all—7: To a great extent.

CIO on board was measured as a dummy variable set to 1 if the CIO or equivalent served on the organization's board of directors.

IT unit age was measured as the number of years lapsed since an IT department was first created in the organization.

IT investment intensity was measured as a single-item measure that assessed the percentage of the organization's annual revenue spent on IT relative to its top five direct competitors. The anchors were 1: Much smaller; 4: About the same; 7: much larger.

Firm size was measured as the number of employees in the organization.

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