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The Effect of Information Technology–Enabled Flexibility on Formation and Market Value of Alliances

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This study investigates the effect of information technology (IT) architecture flexibility on strategic alliance formation and firm value. We first examine the effect of three dimensions of IT architecture flexibility (open communication standards, cross-functional transparency, and modularity) on formation of three types of alliances (arm's-length, collaborative, and joint-venture alliances, respectively). Then, we examine how capabilities in IT flexibility can enhance the value derived from alliances. Our sample includes data from 169 firms that are publicly listed in the United States and that span multiple industries. We find that adoption of open communication standards is associated with the formation of arm's-length alliances, and modularity of IT architecture is associated with the formation of joint ventures. We also find that IT architecture flexibility enhances the value of arm's-length, collaborative, and joint-venture alliances. The contribution of IT flexibility to value is greater in the case of collaborative alliances than in arm's-length alliances. Taken together, these findings suggest that appropriate investments in IT can help to facilitate reconfiguration of resources and modification of processes in collaboration-intensive alliances.

Key words: information technology; service-oriented architecture; alliances; Tobin's q; business value of IT
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1. Introduction

Information technology (IT) has transformed the way that firms collaborate. In strategic alliances, collaborative activities include the codevelopment or recombination of products and services, the joint design of systems, and the sharing of managerial or technical expertise. Gulati (1998, p. 293) defines strategic alliances as "voluntary arrangements between firms involving exchange, sharing, or co-development of products, technologies, or services." Both prior research and anecdotal evidence suggest that the value of alliances to firms can be enhanced, not only by optimizing the efficiency or accuracy of supply chain transactions, but also by codifying and mobilizing tacit knowledge and reconfiguring processes for the creation of new boundary-spanning processes (Zollo et al. 2002). The recent experiences of General Motors (GM) and Nissan illustrate the potential importance of these underlying alliance capabilities. GM lost over $4 billion in a failed joint venture with Fiat, whereas Nissan has been able to derive greater value from its joint venture with Renault. The contrasting fate of these joint ventures within the same industry has been attributed to the ability of alliance partners to reconfigure business processes, to transfer managerial and technical capabilities, and to leverage synergies through investments in IT (Mega International 2004, Gomes-Casseres 2005, Cisco Systems 2008).

Whereas prior studies have focused on the effects of IT in reducing transaction and coordination costs in interorganizational relationships (Brynjolfsson et al. 1994, Clemons et al. 1993, McAfee 2005, Mithas et al. 2008), there is not as much empirical evidence regarding the role of flexible IT architecture as an enabler of interfirm collaboration. In the information systems literature, the study of the role of IT in interorganizational relationships has emphasized efficiency and accuracy of transaction processes in existing supply chains (Barua and Lee 1997, Hitt 1999, Mithas and Jones 2007, Rai et al. 2006, Srinivasan et al. 1994). Interfirm alliance capability has also been a subject of extensive research in the strategy literature (Gulati 1999, Kale et al. 2002, Lavie 2007, Zollo et al. 2002), but this body of work has been largely silent on the role of IT in the alliance context.

This study examines whether IT architecture flexibility facilitates strategic alliance formation and enables firms to derive value from alliances. Prior literature suggests that IT architecture flexibility is a multidimensional construct broadly comprised of open communication standards (Gosain et al. 2005, Sahaym et al. 2007), cross-functional transparency (Malhotra et al. 2005, Pavlou and El Sawy 2006, Sambamurthy et al. 2003), and modularity of IT architecture (Byrd and Turner 2000, Duncan 1995, Gosain et al. 2005, Sanchez and Mahoney 1996). We examine the relationship between each of these dimensions and three different types of strategic alliances: arm's-length, collaborative, and joint-venture alliances. We also examine the effect of each dimension of IT architecture flexibility on the value derived from each of these alliance types respectively. Finally, we examine the extent that IT architecture flexibility, as a single construct comprised of all three dimensions, enables firms to derive greater value from strategic alliances. By distinguishing alliances by the relative depth of interfirm collaboration activities or governance form, we discern how each dimension of flexibility plays a distinct role in enabling and deriving value from the formation of alliances. We use data from a panel of 169 firms that are publicly listed in the United States and that span multiple industries; these firms have collectively engaged in 3,129 documented alliances over a period of seven years from 2000 through 2006.

2. Theoretical Framework

Before proposing hypotheses for alliance formation and alliance value, we discuss a taxonomy of alliances that we use in the subsequent discussion. We define arm's-length alliances as alliances in which two or more firms agree to provide, sell, or exchange a service or product. In these alliances, firms share information or license rights to a product, but activities involving joint development, integration, or recombination of processes or capabilities are relatively absent. Arm's-length alliances are loosely coupled in governance form or in the configuration of interfirm business processes (Orton and Weick 1990, Ray et al. 2009, Sahaym et al. 2007, Schilling and Phelps 2007). In the market-hierarchy continuum, arm's-length alliances most closely resemble market transactions (Oxley 1997). Arm's-length alliances are better suited for the transfer of highly codified capabilities across firm boundaries than they are for the sharing of tacit or firm-specific knowledge needed to codevelop new products or services (Schilling and Phelps 2007). Arm's-length alliance partnerships tend to form quickly and with minimal friction or firm-specific investment.

We define collaborative alliances as those that include any of the following characteristics: (1) sharing of firm-specific or tacit knowledge, such as in joint design or development (Anand and Khanna 2000, Gulati and Singh 1998, Zollo et al. 2002); (2) recombination of products, services, or processes across organizational boundaries (Eisenhardt and Martin 2000, Zollo et al. 2002); or (3) heavy coupling of interorganizational business processes (Gosain et al. 2005, Kim and Mahoney 2006, Zaheer and Venkatraman 1994). Unlike in arm's-length alliances, collaborative alliances involve a substantial sharing of tacit knowledge or recombination of firm resources. Collaborative alliances involve leveraging and recombining tacit knowledge and embedded routines, and are often coordination intensive across multiple firm functions. For instance, the Sun/Intentia alliance created a joint competency center involving multiple facets of customer support, sales, marketing, engineering, and testing (see Table A.2 of the appendix). Collaborative relationships such as these foster conditions that enable the joint creation of knowledge. Existing products and services may be recombined to create novel products or services. Rather than a single interface or point of transmission through which partnering firms might exchange data, collaborative alliance partners create channels of communication across multiple functional areas and seek opportunities to recombine multiple capabilities across organizational boundaries.

We also distinguish alliances by their equity basis, which is a common practice in the alliance literature (Anand and Khanna 2000, Inkpen 2008, Inkpen and Currall 2004). Equity joint-venture alliances (or joint ventures) can be either collaborative or arm's-length, and can have features of both. However, what distinguishes joint ventures from nonequity alliances is that they involve the allocation of partner resources to create an entirely new business entity (Inkpen and Currall 2004). Such alliances also involve bilateral investments in capital, technology, and firm-specific assets (Gulati and Singh 1998). Compared to nonequity alliances, joint ventures involve greater firm-specific assets and include activities that are more collaborative (Anand and Khanna 2000, Gulati and Singh 1998, Oxley 1997). For these reasons, we consider joint ventures as a third separate category based on their governance form, even as their activity content may share features of arm's-length and collaborative alliances.

We next discuss how three dimensions of flexible IT architecture (open communication standards, cross-functional transparency, and modularity) can play a distinct role in enabling three types of alliances: arm's-length, collaborative, and joint-venture alliances. Then, we discuss the moderating influence of flexible IT infrastructure on the firm-performance effects of alliance activity.

2.1. IT-Enabled Flexibility and Alliance Formation

2.1.1. Open Communication Standards and Arm's-Length Alliance Formation. Adoption of open standards is an essential dimension of IT flexibility because it allows business partners to rapidly connect, engage, and establish automated communication (Chatterjee et al. 2006, Gosain et al. 2005, McAfee 2005). Gosain et al. (2005, p. 14) define standards as agreements among business partners "on the syntax, semantics, and pragmatic aspects of documents that are to be exchanged for the specific process being coordinated." An important distinction is to be made between open communication standards and proprietary or bilaterally established standards such as electronic data interchange (EDI), which require substantial firm-specific investments on the part of one or both partners (Clemons et al. 1993, Kim and Mahoney 2006, Venkatraman 1994). Proprietary standards can lead to inflexibility in disconnecting or switching to new partners, or in changing the scope of the relationship (Gosain et al. 2005). Open standards such as those based on Extensible Markup Language (XML), on the other hand, allow for greater flexibility in establishing automated communication between firms (Chatterjee et al. 2006, Moore 2001, Zhu et al. 2006).

We argue that adoption of open communication standards is associated with formation of arm's-length alliances. Prior research provides two theoretical explanations for this. First, the adoption of open standards reduces asset specificity in interfirm technology investments (Sahaym et al. 2007; Schilling and Phelps 2007; Williamson 1981, 1983). Asset specificity in interfirm technology leads to transaction hazards, which firms would try to mitigate by resorting to tightly intertwined partnerships (Kim and Mahoney 2006; Mithas et al. 2008; Williamson 1981, 1983; Zaheer and Venkatraman 1994). Adoption of open standards enables partners to choose arm's-length partnerships instead of resorting to tightly intertwined partnerships. Second, due to issues of organizational culture or competitive positioning, some potential partners are incompatible in forming deeply interdependent alliance relationships and are only willing to engage in arm's-length partnerships with each other. Without open communication standards, alliance partners would need to make asset-specific investments to establish new bilateral communication linkages such as through EDI, which would undermine the arm's-length nature of the relationship. Open communication standards enable such firms to form arm's-length partnerships when they would otherwise choose not to form any partnership at all.

Hypothesis 1A (H1A). *Adoption of open communication standards is associated with formation of arm's-length alliances.*

2.1.2. Cross-Functional Transparency and Collaborative Alliance Formation. We argue that cross-functional transparency enables firms to engage in alliances that are of a collaborative nature. We define cross-functional transparency as capabilities that are widely deployable, visible, and accessible across different functions in a firm. This definition draws upon related work in prior information systems literature that describes the constructs of digital reach (Sambamurthy et al. 2003), partner-enabled knowledge creation (Malhotra et al. 2005), and functional competency (Pavlou and El Sawy 2006). Without cross-functional transparency, functional areas are more likely to be run in isolation as separate silos (Pavlou and El Sawy 2006, Sambamurthy et al. 2003). Whereas open communication standards enable firms to establish communication channels more easily, cross-functional transparency facilitates collaboration across many functional areas, enabling new joint innovation projects to take place (Malhotra et al. 2005).

Cross-functional transparency can expose mutual capabilities among partners and hence create opportunities for joint innovation. Hagel and Brown (2001, p. 113) refer to this as "the ability to discover and orchestrate distinctive capabilities across enterprises," in which firms "find themselves turned inside out, with their formerly well-guarded core capabilities visible and accessible to all." This is important in collaborative alliances, which involve greater complexity of interfaces and recombination of tacit resources among alliance partners. The high coupling of business processes and exchange of tacit knowledge in collaborative alliances means that they are not only more challenging to form than arm's-length alliances, but also that detecting opportunities for creating value may be more difficult. Without cross-functional transparency, the opportunities for value-creation through recombination are more likely to go undetected (Galunic and Rodan 1998). By increasing the visibility and transparency of knowledge within firms, this dimension of flexible architecture can enhance entrepreneurial alertness and enable firms to extend existing assets to new contexts in collaborative alliances (Sambamurthy et al. 2003). Therefore, cross-functional transparency should increase the likelihood that new collaborative initiatives that integrate multiple functional areas are formed.

Hypothesis 1B (H1B). *Cross-functional transparency is associated with formation of collaborative alliances.*

2.1.3. Modularity of IT Architecture and Formation of Joint Ventures. Modularity of enterprise functions embodies a third essential dimension of flexible IT architecture (Duncan 1995, Gosain et al. 2005, Natis and Schulte 2003). Modularity of IT architecture enables the firm to decompose processes into atomic, fine-grained units of functionality, referred to as software components, modules, objects, or services, which can then be recombined easily with other modules to quickly construct a new process (Sanchez and Mahoney 1996). This capability requires the firm to be able to design components at appropriate levels of granularity and resiliency so that they can be more easily added, replaced, or invoked in novel ways without needing to be rebuilt (Prahalad and Krishnan 2008). By enabling rapid and fine-grained decomposability of business logic or processes, the firm significantly enhances the flexibility of its business processes and is then able to adapt quickly to changes in business requirements driven by market conditions or strategy (Mithas and Whitaker 2007). This becomes particularly useful in the large-scale reconfiguration of business processes, particularly when a new operating entity is formed as a result of a partnership. This also allows for separability of key functions, which reduces the costs of reconfiguration and enables the creation of new highly integrated entities.

We argue that modularity of IT enhances the likelihood of formation of new business entities as required in joint ventures, by reducing the cost of reconfiguring existing business processes. Among alliance types, joint ventures require a greater degree of task integration in their formation, under conditions of high "uncertainty and decision-making urgency" (Inkpen and Currall 2004, p. 587). Joint ventures are also dynamic and coevolving systems of collaboration, which further compounds the complexity of integration (Inkpen 2008, Inkpen and Currall 2004). This requires a substantial ability to disaggregate and reaggregate aspects of firm capabilities and processes, and thus modularity is an important enabler of joint venture formation. Modularity of organizational form, which facilitates the creation of new business entities (Ethiraj and Levinthal 2004, Sanchez and Mahoney 1996, Schilling and Phelps 2007), is enhanced in the modularity of IT architecture. By enabling flexibility and agility in creating new business entities, modularity in IT architecture enables firms to engage in more joint ventures.

Hypothesis 1C (H1C). *Modularity of IT architecture is associated with formation of joint ventures.*

2.2. Dimensions of IT-Enabled Flexibility in Alliance Value

Thus far, we have linked individual dimensions of architecture flexibility to formation of specific types of alliances. We next consider whether each of these dimensions of IT flexibility enables firms to derive greater value from the corresponding alliances. Although IT architecture flexibility is not immediately reflected in accounting measures such as sales, it may be valued by market investors along with other IT capabilities (Anand and Khanna 2000, Chan et al. 1997). Prior studies have argued for the use of firm-value-based constructs in studying the performance impacts of investments in IT, because such forward-looking measures are less vulnerable than accounting-based measures to idiosyncrasies of accounting practice (Bharadwaj et al. 1999, Brynjolfsson et al. 2002, Chari et al. 2008). Thus, we consider the value implications of aligning each dimension of IT flexibility to a respective type of alliance.

Hypothesis 2A (H2A). *Adoption of open communication standards has a positive moderating influence in the effect of arm's-length alliances on firm value.*

Hypothesis 2B (H2B). *Cross-functional transparency has a positive moderating influence in the effect of collaborative alliances on firm value.*

Hypothesis 2C (H2C). *Modularity has a positive moderating influence in the effect of joint ventures on firm value.*

2.3. Overall IT-Enabled Flexibility in Alliance Value

Although the individual dimensions of IT flexibility may have a direct link in association with specific alliance formation types, it is conceivable that the individual dimensions of flexibility may not in isolation be sufficient to enable firms to derive value from alliances. Thus, we conceptualize a single construct of IT architecture flexibility that comprises all three dimensions and consider how IT architecture flexibility helps to derive value from each of these types of alliances.

Even as alliances are formed, business requirements change and lead to changes in established interfirm processes. Without sufficient modularity, arm's-length alliance partners would be more likely to build firm-specific software patches that undermine the loosely coupled nature of the relationship (Erl 2007). Modularity reduces relation-specific commitments, should the need arise to modify interfirm processes (Baldwin and Clark 2000, Byrd and Turner 2000, Erl 2007). Without cross-functional transparency, firms would be more likely to create redundant functionality or miss opportunities to create new value. IT architecture flexibility enables firms in arm's-length alliances to avoid excessive integration and protect the loosely coupled nature of the relationship. Therefore, we argue that overall IT architecture flexibility can enhance the value that firms derive from arm's-length alliances.

Hypothesis 3A (H3A). *Flexible IT architecture has a positive moderating influence in the effect of arm's-length alliances on firm value.*

Because collaborative alliances involve the sharing or tacit exchange of knowledge, they require transformation and integration of products, systems, or processes. These capabilities can be enhanced by flexibility in business processes. Besides enhanced sensing of opportunities through cross-functional transparency, the other two dimensions of flexibility allow the firm to successfully exploit opportunities and to implement new initiatives more effectively in the course of collaborative relationships.

Hypothesis 3B (H3B). *Flexible IT architecture has a positive moderating influence in the effect of collaborative alliances on firm value.*

Because joint ventures involve the creation of new business entities, they have high reconfiguration costs in formation. Modularity of IT facilitates the creation of new business entities by helping firms to reconfigure operational processes. Adoption of open standards and cross-functional transparency can also complement modularity and help alliance partners mitigate high reconfiguration costs in the coevolution of shared capabilities. In joint ventures, firms become tightly bound together in a governance form that resembles a hierarchical arrangement (Gulati and Singh 1998, Inkpen 2008, Inkpen and Currall 2004, Oxley 1997, Zollo et al. 2002). This increases the likelihood that alliance partners will need to coevolve the relationship as business conditions require it, because the governance mechanism is designed to make dissolution of the alliance difficult (Inkpen and Currall 2004, Young-Ybarra and Wiersema 1999). In addition to modularity, open standards and cross-functional collaboration help make the modular components reusable, interchangeable, and valuable in many business contexts.

Hypothesis 3C (H3C). *Flexible IT architecture has a positive moderating influence in the effect of joint ventures on firm value.*

3. Research Design and Methodology

3.1. Data

The data for this study come from several sources. First, we utilized data on firms' flexible IT architecture practices reported in the *InformationWeek* 2003 survey. *InformationWeek* surveys are considered reliable and have been used in prior studies (Bharadwaj et al. 1999, Rai et al. 1997). We also obtained data on annual IT investment from *InformationWeek* surveys from 2000 to 2006, which was the basis for construction of a panel data set. Because IT flexibility measures were provided in only one year, those measures were treated as invariant, whereas other measures such as alliance formation activity, IT investment, and other variables varied year over year. Although it is possible that firms' utilization of practices related to IT architecture flexibility varied over the time of the panel, such practices would have developed slowly and over at least a multiple number of years (Natis and Schulte 2003). A panel from 2000–2006 is short enough to assume that the flexible IT architecture practices are constant over this period, and it is long enough to correct for potential unobserved heterogeneity and endogeneity through fixed-effects panel analysis. To check the sensitivity of results to this assumption, we used different windows of time in estimation models. Although different firms are included in the *InformationWeek* sample in each year, a given firm is present for an average of three out of the seven years.

Second, for firms in the final sample, we retrieved 3,129 alliance announcements from the SDC Platinum database (a product of the Thomson Reuters Corporation) in the period from 1996 to 2006. Although it does not track every deal entered into by U.S. firms, SDC Platinum is considered to be among the most comprehensive sources of data on alliances and has been used in many prior academic studies (Anand and Khanna 2000, Lavie 2007, Schilling 2009). Alliance records in the SDC database included dates, deal type, descriptions, names, and Standard Industrial Classfication codes of all participating firms, a listing of activities involved in the alliance, and a flag indicating whether the alliance was a joint venture. Less than 7% of the alliances retrieved from the SDC database involved two or more firms included in the *InformationWeek* data. The rest involved an alliance between an in-sample focal firm, for which we had *InformationWeek* data, and out-of-sample partners for which we had no firm-level data on IT investment or IT architecture flexibility practices. In many cases, however, we were able to obtain other firm-level or industry-level characteristics of partner firms from Compustat and the Bureau of Economic Analysis. To verify the representativeness of alliance counts in our data set with the actual population of alliances, we used a random number generator to select 10% of firms in the final sample and conducted comprehensive manual searches for alliance formation announcements in Factiva news database between the years of the study period. We found a statistically significant correlation of 0.81 ($p < 0.001$) between the SDC alliance counts and Factiva alliance announcement counts. Our findings are consistent with those of Schilling (2009), who showed that the alliance listings in the SDC database are well representative of the population of alliances particularly when, as in the current study, the sample consists primarily of large firms operating in technology-intensive industries.

Finally, we retrieved performance variables as well as firm-level and industry-level controls from the Compustat North America database. We also gathered these data on each of the focal firms' alliance partners whenever they were available. Our final sample includes 169 publicly listed firms representing 50 different industries at the three-digit North American Industry Classification System (NAICS) level.

3.2. Variables

Our measure of IT architecture flexibility is based upon adoption and use of service-oriented architecture (SOA) by the firm, which are closely associated with the flexibility-related capabilities of process reconfiguration and opportunity detection (Chatterjee et al. 2006, Cherbakov et al. 2005, Erl 2007, McAfee 2005). The IT architecture flexibility measure reflects four dimensions: (1) the use of XML, a common data representation language that is used in SOA (*Open standards*); (2) the number of business functions for which Web services are used, which proxies for firm wide breadth of Web service use (*Cross-functional transparency*); (3) the deployment of a services-based architecture *(Modularity)*; and (4) the use of technical standards that comprise an "enabling layer" on top of which SOA is built (*SOATechLayer*). Because each of the dimensions of SOA has a different scale, we standardized the SOA measure components *Modularity*, *Open standards*, *Cross-functional transparency*, and *SOATechLayer*. The indicators are not necessarily interchangeable, and the direction of causality flows from these indicators to the main construct. Hence, according to the criteria of Jarvis et al. (2003), these are formative indicators. An unrotated principal components analysis reveals that all items comprising the measure of SOA load positively onto the first principal component, with weightings for each of between 0.41 and 0.56. Hence, we use the first principal component in all subsequent analysis. Further details about the SOA measures are provided in the appendix.

The measures of alliance formation are the number of new alliance announcements in any given year. Alliances are classified as either collaborative (*Collab*) or arm's-length alliances (*Arm's-len*), and also either as joint ventures (*JV*) or nonequity alliances (*Non-Eq*). Joint ventures are easy to identify because they are based on a binary variable that is given in the original SDC Platinum data set of alliances, and this source has been used and found reliable in many prior studies (Anand and Khanna 2000, Schilling 2009). We developed and validated a procedure of automated content analysis to classify each of the 3,129 alliances as collaborative or arm's-length. Using a set of simple coding rules, we classified each alliance as collaborative or arm's-length based upon the "deal text" field provided in the SDC Platinum database. Finally, we examined the outcome of automated coding for both sufficient variation in data, robustness of results, and consistency with manual coders. Further details about these measures are given in the appendix.

The measure of firm value is Tobin's q (Q), which has been used to measure the performance impacts of alliances as well as of IT investment (Bharadwaj et al. 1999, Lavie 2007): Tobin's $q = (MVE + PS + DEBT)/TA$, where PS is the liquidating value of the firm's outstanding preferred stock, and TA is the book value of total assets. MVE is the average of 12 end-of-month market values of equity obtained from the Center for Research in Security Prices, which makes this measure less vulnerable to end-of-year market volatility. Consistent with Bharadwaj et al. (1999), $DEBT$ is calculated as follows: $DEBT =$ (current liabilities $-$ current assets) $+$ (book value of inventories) $+$ (long-term debt).

Among the control variables, IT intensity (*IT*) serves as a proxy for overall information intensity of a firm's operations. IT intensity is measured as the percentage of revenue represented by the firm's total worldwide IT budget. IT expenditure includes hardware, software, network infrastructure, salaries and recruitment of IT professionals, Internet-related costs, and IT-related services and training. Given the comprehensiveness of this measure in capturing all of a firm's IT-related expenses, this construct is a proxy for overall information intensity of a firm's operations. For a limited portion of the sample, we were able to obtain measures of partner characteristics, including number of employees, research and development (R&D), advertising, free cash flow, profitability, and industry-average IT investment. We also include control for size of the alliance based upon capitalization values, either estimated or stated in the alliance announcement. All control variables are defined in the appendix. Table 1 shows summary statistics and correlations.

3.3. Estimation Models

3.3.1. Models for Alliance Formation. We use count models because the alliance formation variable is a discrete and positive integer. A common approach in modeling count data is to use the Poisson model, which assumes that the mean and variance of the dependent variable are equal. Because alliance counts show some overdispersion, we also report the negative binomial panel models. For both Poisson and negative binomial models, we utilize panel random-effects models to account for persistent individual unobserved effects. In all models, the likelihood ratio comparing model estimates to the corresponding pooled models are significant, suggesting that panel count models are appropriate. We also control for year and industry fixed effects, along with a number of

Table 1 Summary Statistics and Correlations

	N	M	SD	1	2	3	4	5	6	7	8	9	10
1 *Q*	1,126	1.47	1.33	1.00									
2 *Arm's-len*	1,010	0.53	1.45	0.30	1.00								
3 *Collab*	1,010	0.43	1.36	0.35	0.71	1.00							
4 *JV*	1,010	0.28	1.03	0.26	0.20	0.33	1.00						
5 *Non-Eq*	1,010	1.37	3.98	0.44	0.52	0.49	0.62	1.00					
6 *SOA*	635	0.12	1.28	0.14	0.11	0.10	0.03	0.12	1.00				
7 *Open standards*	635	−0.01	0.95	0.12	0.11	0.10	0.05	0.12	0.71	1.00			
8 *Transparency*	635	0.14	1.00	0.11	0.15	0.14	0.03	0.18	0.72	0.34	1.00		
9 *Modularity*	635	0.07	1.01	0.04	0.00	−0.04	0.03	−0.03	0.51	0.20	0.18	1.00	
10 *IT*	1,126	0.03	0.03	0.12	0.08	0.04	0.00	0.07	0.02	0.00	0.08	0.02	1.00
11 *Alliance size*	1,126	180.52	683.50	0.45	0.50	0.54	0.68	0.94	0.12	0.11	0.13	−0.01	0.06
12 *Ind. cap. intens.*	1,126	0.29	0.18	−0.23	−0.14	−0.12	−0.07	−0.18	0.00	−0.07	0.02	−0.06	−0.15
13 *Herfindahl index*	1,126	0.07	0.08	−0.07	−0.07	−0.10	−0.05	−0.07	−0.07	−0.11	−0.05	−0.02	0.00
14 *Regulation*	1,126	0.16	0.37	−0.03	−0.06	−0.10	−0.06	−0.06	0.01	−0.03	0.01	−0.09	0.06
15 *Market share*	1,126	0.04	0.07	0.00	−0.01	−0.05	0.07	0.05	−0.03	0.00	0.01	0.03	−0.04
16 *Diversification*	1,126	0.21	0.44	−0.12	−0.03	−0.02	0.12	−0.06	−0.15	−0.06	−0.16	−0.01	−0.04
17 *Employees*	1,126	37.17	52.78	−0.02	0.15	0.13	0.17	0.15	−0.04	−0.02	−0.05	0.02	0.02
18 *Advertising*	1,126	0.03	0.03	0.15	−0.08	−0.07	−0.04	−0.06	0.02	−0.01	0.02	0.04	0.07
19 *R&D*	1,126	0.03	0.05	0.30	0.17	0.20	0.07	0.22	0.12	0.12	0.13	−0.04	0.14
20 *Industry Tobin's q*	1,126	1.27	0.82	0.39	0.07	0.10	0.22	0.22	0.02	0.06	0.02	−0.01	0.09

	N	M	SD	11	12	13	14	15	16	17	18	19	20
9 *Modularity*	635	0.07	1.01										
10 *IT*	1,126	0.03	0.03										
11 *Alliance size*	1,126	180.52	683.50	1.00									
12 *Ind. cap. intens.*	1,126	0.29	0.18	−0.14	1.00								
13 *Herfindahl index*	1,126	0.07	0.08	−0.09	0.06	1.00							
14 *Regulation*	1,126	0.16	0.37	−0.05	0.52	−0.10	1.00						
15 *Market share*	1,126	0.04	0.07	0.02	0.17	0.52	0.04	1.00					
16 *Diversification*	1,126	0.21	0.44	−0.03	−0.11	−0.07	−0.12	−0.08	1.00				
17 *Employees*	1,126	37.17	52.78	0.18	0.04	0.10	−0.06	0.28	0.15	1.00			
18 *Advertising*	1,126	0.03	0.03	−0.06	0.04	0.00	0.07	−0.03	−0.11	−0.09	1.00		
19 *R&D*	1,126	0.03	0.05	0.19	−0.37	−0.20	−0.07	−0.19	−0.09	0.00	−0.10	1.00	
20 *Industry Tobin's q*	1,126	1.27	0.82	0.18	−0.28	−0.05	−0.17	0.04	−0.05	0.02	0.16	0.22	1.00

Note. N, number of observations; M, mean; SD, standard deviation.

firm variables that are considered to influence proclivity to form alliances. We used several techniques to examine the potential effects of endogeneity and simultaneity in robustness checks discussed in §4. Table 2 shows the results of the panel Poisson and panel negative binomial regressions. All regressions are highly significant, as evidenced by the significant Wald chi-square statistics.

3.3.2. Models for IT-Enabled Business Value in Alliances. In theory, alliances create value that is not quantified in the accounting books: intangible interorganizational resources that can generate future profits through the joint development of new products or services (Anand and Khanna 2000, Chan et al. 1997). Hence, we incorporate *ALNCS*, the number of alliances (of any type such as *Collab*, *Arm's-len*, or *JV*) formed annually into a Tobin's *q* framework similar to the model used by Bharadwaj et al. (1999):

$$\begin{aligned} Q_{i,t} &= \beta_o + \beta_{SOA} SOA_i + \beta_{H*} SOA_i \times ALNCS_{i,t} \\ &\quad + \beta_{IT} IT_{i,t} + \beta_A ALNCS_{i,t} + \mathbf{X}_C \boldsymbol{\beta}_C \\ &\quad + \Sigma_t \beta_t \text{ year}_t + \Sigma_i \beta_i \text{ industry}_i + u_i + \varepsilon_{i,t}. \qquad (1) \end{aligned}$$

The matrix $\mathbf{X}_C$ represents controls for capital intensity, Herfindahl index (a measure of industry concentration), industry regulation, market share, diversification, the log of the number of employees, R&D, and advertising. Equation (1) also includes year and industry (two-digit NAICS) dummy variables.

Fixed-effects panel estimation is a simple way to remove the influence of any firm-specific omitted factors that do not vary much over short periods of time (e.g., organizational culture, managerial capability, and brand reputation), relegating any remaining endogeneity to idiosyncratic time-varying unobservables that are comparatively small. We use robust standard errors to correct for possible nonspherical errors. We note that there would be a reason to cluster errors by individual firm or alliance to correct for the sample containing both sides of an alliance dyad. However, this occurs in such small proportion of cases (less than 7%) that the net benefit of such a correction would be negligible. Overall, our results show a similarity in coefficient estimates (in direction and significance) between random- and fixed-effects models, suggesting that the estimates are robust to the

Table 2 How Dimensions of IT Flexibility Relate to Alliance Formation

Panel count model	(1) Poisson	(2) Panel NB	(3) Poisson	(4) Panel NB	(5) Poisson	(6) Panel NB
	Arm's-length	Arm's-length	Collab	Collab	JV	JV
H1A	0.231**	0.205**	0.0756	0.155	−0.0165	−0.0400
Open standards	(0.116)	(0.114)	(0.130)	(0.134)	(0.139)	(0.140)
H1B	0.0950	0.0968	0.113	0.124	0.0561	0.0661
Cross-functional transparency	(0.105)	(0.105)	(0.119)	(0.117)	(0.129)	(0.127)
H1C	0.0770	0.0548	0.0490	0.0452	0.301**	0.299**
Modularity	(0.103)	(0.102)	(0.116)	(0.113)	(0.127)	(0.125)
IT	1.861	1.797	1.738	1.710	2.430*	2.571*
	(1.166)	(1.166)	(1.156)	(1.150)	(1.447)	(1.420)
log(*Employees*)	0.185**	0.216**	0.242**	0.314***	0.301**	0.307***
	(0.0884)	(0.0906)	(0.101)	(0.104)	(0.119)	(0.117)
Herfindahl index	−2.365	−1.704	−7.734**	−7.969**	−11.26***	−10.77***
	(1.612)	(1.569)	(3.083)	(3.116)	(3.921)	(3.812)
Regulated industry	0.419	0.410	−0.478	−0.532	−0.858	−0.812
	(0.370)	(0.371)	(0.458)	(0.466)	(0.531)	(0.514)
Market share	0.965	0.794	2.053	1.383	7.002**	6.889***
	(2.004)	(1.941)	(2.502)	(2.471)	(2.735)	(2.642)
Rel. diversification	0.187	0.213	0.146	0.138	0.515**	0.460*
	(0.211)	(0.219)	(0.220)	(0.228)	(0.234)	(0.242)
Advertising	−4.825	−5.217	−3.891	−2.889	0.255	0.824
	(4.000)	(4.272)	(4.483)	(4.523)	(4.900)	(4.885)
R&D	0.677	0.724	1.313	1.117	1.879	1.823
	(0.873)	(0.867)	(0.990)	(0.979)	(1.453)	(1.426)
Industry Tobin's q	0.360***	0.388***	0.493***	0.486***	0.318**	0.318*
	(0.0993)	(0.108)	(0.109)	(0.118)	(0.157)	(0.164)
Constant	−1.238***	0.231	−1.742***	0.0108	−2.208***	−0.249
	(0.384)	(0.596)	(0.461)	(0.643)	(0.539)	(0.906)
Wald χ^2	129.0***	113.7***	134.4***	116.7***	108.9***	99.83***
Observations	702	702	702	702	702	702
Number of firms	172	172	172	172	172	172

Notes. Panel Poisson and negative binomial (NB) regression models (172 firms, 702 observations) with random effects are shown. The dependent variable is *number of alliances formed per year*. The models also include two-digit NAICS industry and year dummy variables. Standard errors are in parentheses.
*Significant at 10%; **significant at 5%; ***significant at 1%.

choice of panel estimator. Because the coefficients of interest are the interaction terms that vary over time, we rely on fixed-effects estimators, which have better consistency properties than random-effects or pooled ordinary least squares (OLS) estimators (Greene 2003). Along with fixed-effects estimates, we also present pooled OLS results to show cross-sectional effects in the data.

We estimated each model with and without additional controls for alliance partners, including R&D, advertising, cash flow, profitability, and number of employees of alliance partners. Because these control variable data are not available for all alliance partners, sample size is substantially reduced when alliance partner control variables are included. The coefficients of interaction terms of interest remain similar in magnitude, direction, and significance, suggesting that we can rely on the larger sample, which does not include these additional controls.

4. Results

Table 2 presents results for our first set of hypotheses linking three dimensions of IT-enabled flexibility with three types of alliances. Hypothesis 1A, which predicts that open standards are associated with a greater likelihood of arm's-length alliance formation, is supported ($p < 0.10$). We did not find support for Hypothesis 1B, which predicts that cross-functional transparency is associated with a greater likelihood of collaborative alliance formation. Hypothesis 1C, which predicts that modularity is associated with a greater likelihood of joint venture formation, is supported ($p < 0.05$). We also find that the other dimensions of flexibility are less important for the formation of joint ventures; that is, joint venture formation is not associated with cross-functional transparency and open standards. The results support prior theory linking open communication standards with lower asset specificity (Sahaym et al. 2007), and also support our hypothesis linking modularity with joint ventures, which involve the joint creation of new business entities.

Table 3 presents results for our second set of hypotheses linking three dimensions of IT-enabled flexibility with value derived from three corresponding types of alliances. Hypothesis 2A, which predicts that adoption of open standards has a positive influence on value derived from arm's-length alliances, is supported ($p < 0.05$). Hypothesis 2B, which predicts that cross-functional transparency has a positive influence on value derived from collaborative alliances, is also supported ($p < 0.01$). We did not find support for Hypothesis 2C, which predicts that modularity has a positive influence on value derived from joint ventures. Regarding the other six componentwise interactions that were not hypothesized, we did not find statistically significant interaction effects except, surprisingly, in the negative interaction between modularity and arm's-length alliances. It may be that modularity itself, without sufficient cross-functional transparency or open communication standards, may undermine the value of arm's-length alliances. This underscores the need to examine the effect of IT flexibility as a single combined construct.

Table 3 Componentwise Moderating Effect of IT Flexibility Dimensions on Tobin's *q*

Variables	(1) Tobin's *q*
β_{H2A}: *Open standards* × *Arm's-len*	0.0767**
	(0.0382)
β_{H2B}: *Cross-func. transparency* × *Collab*	0.130***
	(0.0481)
β_{H2C}: *Modularity* × *JV*	−0.0689
	(0.106)
Modularity × *Arm's-len*	−0.0583*
	(0.0344)
Cross-func. transparency × *Arm's-len*	0.0422
	(0.0320)
Modularity × *Collab*	−0.00487
	(0.0436)
Open standards × *Collab*	0.0162
	(0.0573)
Cross-func. transparency × *JV*	0.111
	(0.0869)
Open standards × *JV*	0.0516
	(0.109)
JV	0.158*
	(0.0837)
Collab	−0.0320
	(0.0522)
Arm's-len	−0.0386
	(0.0313)
Alliance size	0.000487***
	(0.000147)
IT	0.527
	(0.827)
R^2	0.574
F-statistic	31.22***
Observations	635
Number of firms	169

Notes. A fixed-effects panel regression is shown. The model also includes two-digit NAICS industry and year dummy variables, industry capital intensity, industry regulation, market share, diversification, advertising, R&D, industry Tobin's *q*, log of employees, and the Herfindahl index. Robust standard errors are in parentheses.

*Significant at 10%; **significant at 5%; ***significant at 1%.

We found broad support for the notion that flexible IT architecture, as a single combined construct, will enhance the value creation in three types of alliances. Hypotheses 3A–3C predict that SOA will have a positive influence on the value contribution of each arm's-length, collaborative, and joint-venture alliance, respectively. In the case of arm's-length alliances, H3A is weakly supported; as seen in the fixed-effects panel results in Table 4 (column (3); $\beta_{H3A} = 0.0443$, $p < 0.05$, two-tailed t-test).

Hypothesis 3B predicts that SOA will have a positive influence on the value contribution of collaborative alliances. Estimation results in Table 4 support this hypothesis (column (3); $\beta_{H3B} = 0.142$, $p < 0.01$, two-tailed t-test). Coefficient estimates show this moderating effect to be greater in the case of collaborative alliances than in arm's-length alliances, as indicated by a comparative F-test significant at the 5% level. This does not appear to be driven by the size or inherent value of these alliances, because we control for size as well as direct effects. This suggests that IT architecture flexibility is particularly valuable when firms need to recombine resources or detect opportunities in the context of tacit knowledge exchange, capabilities that are required in collaborative alliances.

Hypothesis 3C predicts that SOA will have a positive influence on the value contribution of each joint venture. Table 4 shows the effect of SOA with joint ventures along with alliances that are not joint ventures (*Non-Eq*), and shows that Hypothesis 3C is supported (column (6); $\beta_{H3C} = 0.217$, $p < 0.01$).[1] Overall, the findings suggest that the three dimensions of flexibility together are complementary in generating

[1] The models in Table 4 examine collaborative versus arm's-length alliances and joint ventures versus nonequity alliances separately. As discussed in the appendix (and shown in Table A.3), these are alternative classifications of alliances although they have important conceptual distinctions. Joint ventures tend to be (but are not always) collaborative alliances, whereas nonequity alliances tend to be (but are not always) arm's-length alliances. Thus, combining all four types of alliances into a single firm-value model leads to collinearity and inflated errors of coefficient estimates. However, for the sake of completeness, we estimated OLS, random-effects, and fixed-effects models (with the same control variables) in which collaborative, arm's-length, and joint-venture alliances are included together, and verified that Hypotheses 3A–3C are supported in such models as well.

Table 4 Moderating Influence of SOA in the Effect of Alliance Formation on Firm Value

	(1)	(2)	(3)		(4)	(5)	(6)
Variables	OLS	FE panel IVREG	FE	Variables	OLS	FE panel IVREG	FE
SOA	0.0721*** (0.0264)			*SOA*	0.0747*** (0.0283)		
Arm's-len	−0.124** (0.0516)	−0.0973 (0.145)	−0.0204 (0.0315)	*Non-Eq*	−0.111*** (0.0352)	−0.259** (0.117)	−0.0163 (0.0269)
Collab	−0.0117 (0.0705)	−0.129 (0.189)	0.0948*** (0.0342)	*JV*	0.0597 (0.110)	0.593* (0.312)	0.140** (0.0551)
Alliance size	0.749*** (0.225)	1.13*** (0.377)	0.559*** (0.121)	*Alliance size*	0.951*** (0.256)	0.749 (0.517)	0.704*** (0.129)
β_{H3A}: *SOA* × *Arm's-len*	0.0593 (0.0360)	0.0547 (0.0442)	0.0443** (0.0184)	*SOA* × *Non-Eq*	0.0492** (0.0217)	0.143*** (0.0416)	0.0459** (0.0177)
β_{H3B}: *SOA* × *Collab*	0.107*** (0.0368)	0.180*** (0.0459)	0.142*** (0.0202)	β_{H3C}: *SOA* × *JV*	0.211*** (0.0787)	0.149*** (0.0482)	0.217*** (0.0315)
IT	1.30 (1.32)	−0.0405 (1.168)	0.0306 (1.088)	*IT*	1.18 (1.29)	0.879 (1.324)	0.0611 (1.089)
Ind. cap. intens.	−0.995*** (0.203)	2.122 (1.608)	2.157 (1.532)	*Ind. cap. intens.*	−1.06*** (0.208)	2.114 (1.805)	1.982 (1.532)
Herfindahl index	−0.445 (0.695)	−3.499* (1.915)	−3.104* (1.811)	*Herfindahl index*	−0.427 (0.695)	−1.924 (2.260)	−3.064* (1.815)
Regulated industry	0.0772 (0.127)			*Regulated industry*	0.0867 (0.130)		
Market share	0.949 (0.609)	0.945 (1.889)	0.872 (1.777)	*Market share*	0.872 (0.620)	0.871 (2.105)	1.004 (1.777)
Rel. diversification	−0.0971 (0.0671)	0.118 (0.233)	0.175 (0.219)	*Rel. diversification*	−0.120* (0.0709)	−0.0364 (0.268)	0.132 (0.219)
log(*Employees*)	0.0296 (0.0381)	−0.0987 (0.136)	−0.0697 (0.114)	log(*Employees*)	0.0219 (0.0389)	−0.176 (0.143)	−0.0564 (0.114)
Advertising	10.4*** (1.83)	2.937 (3.186)	2.128 (2.976)	*Advertising*	10.6*** (1.83)	0.223 (3.763)	1.336 (2.985)
R&D	3.20** (1.32)	−0.176 (2.374)	−0.629 (2.242)	*R&D*	3.33** (1.33)	−2.668 (2.804)	−0.576 (2.246)
Industry Tobin's q	0.664*** (0.0851)	0.726*** (0.113)	0.673*** (0.101)	*Industry Tobin's q*	0.682*** (0.0845)	0.792*** (0.125)	0.715*** (0.101)
R^2	0.495	0.438	0.489	R^2	0.507	0.291	0.489
Wald χ^2		4,786***		Wald χ^2		3,804***	
F-statistic	16.39***		22.50***	*F*-statistic	15.34***		22.48***
Hausman Comparison		2.60 ($p = 1.00$)		Hausman Comparison		7.15 ($p = 0.99$)	
Sargan (overidentification)		2.90 ($p = 0.41$)		Sargan (overidentification)		1.62 ($p = 0.44$)	
Anderson (1984) Lagrange multiplier (underidentification)		10.90**		Anderson (1984) Lagrange multiplier (underidentification)		19.69***	

Notes. Fixed-effects instrumental variables (FE Panel IVREG) and panel fixed-effects models (FE) ar shown. The dependent variable is Tobin's *q*. The sample size is 635 observations for 169 firms. Instruments for *Arm's-len*, *Collab*, *JV*, and *Non-Eq* are one-, two-, and three-year lagged values of alliance partners' resources and investments (total income before extraordinary items, earnings per share including extraordinary items, income taxes, and depreciation and amortization). Models also include two-digit indicators for NAICS industry, year dummy variables, and a constant term. Sample sizes are restricted based on availability of excluded instruments. Hausman test statistics show no significant differences between fixed-effects panel instrumental variables estimates and standard fixed-effects estimates. Standard errors are in parentheses.

*Significant at 10%; **significant at 5%; ***significant at 1%.

value from alliances, although individual dimensions may not by themselves have positive and significant moderating effects. Variance inflation factors (VIFs) are below 5.7 for all variables, with a mean VIF of 1.95, suggesting no substantial multicollinearity in these models.

We note that the marginal effect of IT investment appears less significant here than in estimates reported by Bharadwaj et al. (1999). Using the same models and variables restricted to the set used in the previous study, we also find that IT investment has a positive and significant effect on Tobin's *q*.[2] As expected, the marginal effect of IT

[2] In restricted models, our base estimate for the IT coefficient is 3.40 for OLS ($p < 0.01$), and 1.54 in random-effects estimation ($p < 0.10$).

investment becomes smaller in models that also include SOA. Whereas IT investment represents the financial resources invested to develop IT capabilities, the SOA measure is a more direct proxy of an actual aspect of IT capability (IT flexibility). In light of our theory emphasizing the importance of IT flexibility in the alliance context, the inclusion of alliance formation variables and interactions between alliances and SOA should also result in a lower marginal effect of IT. Further differences in model estimates can be attributed to the smaller size of our final sample (firms reporting SOA measures) and the use of fixed-effects models, which remove cross-sectional effects in the data.

We conducted several robustness checks. First, we tested for the effects of possible endogeneity and simultaneity in the number and type of alliances in which firms decide to engage. For models of alliance formation, we conducted seemingly unrelated Poisson and seemingly unrelated negative binomial regressions and found the same statistical significance of hypothesized coefficient estimates as in our reported panel count models, indicating that simultaneous errors across models are not influential. Because pure instrumental variables for SOA are not available, we used a simple approach introduced by Wooldridge (2005) to account for unobserved effects in nonlinear panel models. This technique incorporates a lagged dependent variable and a proxy for initial value of formation of three alliance types (using data from four years before the sample period) into the panel count models. The coefficient estimates of such models have the same direction and statistical significance as in the regular panel count models that we report, and Hausman comparison tests do not indicate any significant differences between model estimates.

Second, we consider potential endogeneity in models for IT-enabled business value, using panel fixed-effects instrumental variable regression results. We used two- and three-year lagged changes in alliance partners' resources and investments (total income before extraordinary items, earnings per share including extraordinary items, income taxes, and depreciation and amortization) as instruments for the annual number of focal firms' collaborative and arm's-length alliances, and also for the annual number of joint ventures and nonequity alliances. Results are shown side by side with regular fixed-effects panel estimates in Table 4. The F-statistic of the first-stage regression models and F-test of excluded instruments indicate that the instruments have strong relevance. The statistically insignificant Sargan statistic does not cast doubt on orthogonality of excluded instruments with model residuals (Wooldridge 2002). The Anderson (1984) Lagrange multiplier test for underidentification is statistically significant, suggesting that the models are not underidentified (the rank condition for identification is satisfied). The Hausman test statistic comparing the panel instrumental variable fixed-effects estimates with the standard fixed-effects estimates is insignificant, suggesting that any possible endogeneity in the number of alliances or proportion of alliance types has no significant influence on the hypothesized relationships. Together, these tests suggest that the instrumental variables are valid.

Third, we conducted tests of reverse causality by including forward values of IT and alliance activity in fixed-effects panel regressions and found those forward values to have no significant effects on Tobin's q. In addition, we conducted tests using historical values of Tobin's q in place of the dependent variable—a robustness strategy also carried out by Black and Lynch (2001). These tests reveal no evidence that historical performance influences current alliance network size, SOA, or IT investment.

Fourth, although we believed the period 2000–2006 to be the most appropriate for inclusion of SOA, we also conducted tests that restricted the panel to years 2002 and beyond and found coefficient estimates that are consistent with those presented here, although, as expected, the statistical precision declines somewhat. We also conducted tests (excluding aggregate IT investment) that include the prior years of 1996–1999 in the model and found coefficient estimates that are consistent in direction and significance with those presented here. As might be expected, the evidence suggests that the emergence of SOA was not a sudden exogenous shock. Rather, the measure of SOA appears to be capturing a firm's engagement in a longer-term program to create business process infrastructure flexibility, having probably begun with earlier incarnations of SOA technologies. We also conducted fixed-effects estimates using additional controls for the ratio of international alliances, number of activities per alliance, number of partners per alliance, as well as three-year prior ratios over total alliances of joint ventures, nonequity alliances, technology alliances, marketing alliances, and service alliances. Although these additional controls were only available for a smaller sample size of 479 observations for 150 firms, the resulting fixed-effects estimates were consistent in showing support for the hypotheses.

Finally, we considered sample selection issues. In the context of fixed-effects panel models, it has been

Across all specifications, our coefficient estimates for IT are well within the range of −1.72 to 9.24 in the study by Chari et al. (2008), and reasonably close to the range of 0.15 to 0.70 in the study by Bharadwaj et al. (1999). It is important to note that the firm-performance impacts of IT and other investments can differ over time (see Mithas et al. 2012 for a discussion).

shown that sample selection is only a problem when selection is related to idiosyncratic errors $\varepsilon_{i,t}$, and hence "any test for selection bias should test only this assumption" (Wooldridge 2002, p. 581). Therefore, we conducted the Nijman and Verbeek (1992) test adapted to the fixed-effects panel context, which involves testing for the significance of a lagged selection indicator in fixed-effects panel models. Results of the test suggested no evidence of selection related to idiosyncratic errors. We also tested separately for incidental truncation of the sample, which can occur when key variables are available only for "a clearly defined subset of the population" (Wooldridge 2002, p. 552). We did this by conducting a version of Heckman's test extended to the unobserved effects panel data context, by modeling the selection indicator as a pooled probit function of industry characteristics and alliance activity (Wooldridge 2002). The resulting Mill's ratio showed no significant effect in firm-performance models, indicating no significant influence of incidental truncation in model estimates.

5. Discussion

5.1. Main Findings and Research Implications

To our knowledge this is the first study to examine the quantitative effects of flexible IT infrastructures in the context of strategic alliances, both in formation and value derived from formation. First, we find that open communication standards are associated with greater proclivity to form arm's-length alliances. This finding documents support for the notion that open communication standards reduce firm-specific investments in the establishment of automated communication processes and enable the formation of loosely coupled interorganizational relationships. Second, we show that modularity is associated with the formation of joint ventures. To the extent modularity reduces the costs and risks of reconfiguring business processes (Mithas and Whitaker 2007), the finding suggests that modularity enhances the ability to form new business entities such as in equity joint ventures. We did not find a statistically significant association between cross-functional transparency and formation of collaborative alliances. This may be because firms are not fully aware of the value of cross-functional transparency, or they are not fully leveraging their cross-functional capabilities; or it could be that cross-functional transparency inclines firms to rely more on intrafirm rather than interfirm cooperation. Either of these scenarios would weaken the relationship between cross-functional transparency and collaborative alliances. However, as we observed, cross-functional transparency appears to generate value for firms that form collaborative alliances, even if it does not seem to influence collaborative alliance formation as hypothesized. These findings contribute to the literature on interorganizational relationships by revealing different ways in which alliance formation is tied to flexible IT capabilities.

We also examined the influence of flexible IT architecture on the firm-value effects of alliance formation. First, our findings show that IT architecture flexibility enables firms to derive greater value from arm's-length alliances. We argue that this occurs because IT architecture flexibility makes it possible for alliance partners to maintain a loose coupling and avoid becoming excessively integrated in the course of alliance formation. Second, our findings show that IT architecture flexibility allows the firm to derive greater value from collaborative alliances; we argue that this occurs because IT architecture flexibility enables firms to better exploit opportunities in the course of evolving relationships and to implement new initiatives more effectively. Third, our findings show that IT architecture flexibility enables firms to derive greater value from joint ventures. We argue that this is because IT architecture flexibility reduces the costs of reconfiguring or recombining resources. Our findings suggest that although individual dimensions of flexibility may enable formation of certain types of alliances, all three dimensions of flexible IT architecture together are important in deriving value from such alliances.

We find that the influence of flexible IT on the effect of collaborative alliances on firm value is greater than its influence in the effect of arm's-length alliances on firm value. This finding does not appear driven by the size or value of alliances, because the models include controls for size as well as direct effects of formation on firm value. The comparative result is somewhat surprising because prior theory suggests that greater flexibility should be associated with loosely coupled or arm's-length alliances. It is known that flexibility of IT can enhance the value of arm's-length alliances by enabling frictionless maintenance or termination of loosely coupled processes (Sahaym et al. 2007). However, given the increasing digitization of business processes, we believe that the effect of flexibility in IT architecture is increasingly to enhance the sharing of complex and tacit knowledge, and to enable the reconfiguration or recombination of products and processes. These ideas can be explored further in future research.

5.2. Managerial Implications

Firms invest substantial capital resources and take significant risks in engaging in corporate alliances, often devoting entire departments to the task of managing their alliances (Kale et al. 2002). Greater attention is needed on the role of IT infrastructure and business process capabilities in the execution of alliances, and the resulting effects on firm performance. Our results suggest that strategic flexibility should be considered a cornerstone of metrics used to evaluate the effectiveness of IT investment. Hence, firms need to focus on management of IT and digital resources with care in the decisions, planning, and governance of corporate alliances, particularly in the case of collaborative alliances involving the recombination of resources and reconfiguration of processes.

In assessing the potential impacts of IT, managers need to consider the importance of flexibility in IT infrastructure and in business processes. Such flexibility can enable firms to explore strategic synergies through alliances before engaging in mergers. When the firms Hewlett-Packard (HP) and Compaq merged, managers confronted challenges of operational integration due in part to complex and disparate IT environments, and they were ultimately unable to generate synergies on a strategic level (Burgelman and McKinney 2006). The partnership between HP and Compaq may have been more effective had they first explored and tested their strategic synergies as alliance partners. Managers should identify the specific processes that might interface with those of a partner firm, and consider how those processes need to be transformed using IT. They should also consider how the potential synergies with business partners will help leverage other firm capabilities. Analysts should also pay greater attention to the flexibility of IT architecture when evaluating the market value impact of alliances, particularly in alliances involving close interfirm collaboration.

This study is not without limitations that can be overcome in future work. Although we use a rich set of measures to assess IT-enabled flexibility and the overall flexibility of the IT architecture, we do not know the exact timing of when firms in our sample deployed SOA and related IT applications. Despite use of multiple econometric techniques to rule out alternative explanations, there is a need to exercise caution, and there remains a need to use alternative approaches such as a potential outcomes approach to explore the causal nature of the relationships (see Mithas and Krishnan 2009).

To conclude, we studied the role of IT architecture flexibility on alliance formation and value. We found that adoption of open communication standards is associated with the formation of arm's-length alliances, and modularity of IT architecture is associated with the formation of joint ventures. We also found that the value of alliances is enhanced by overall IT architecture flexibility, as a single construct comprising all three dimensions, suggesting that all three dimensions of flexibility are important in the value derived from arm's-length, collaborative, and joint-venture alliances. Our findings suggest a need for greater consideration of the role of flexibility in IT-driven business processes, in addition to transaction cost and coordination cost reduction, to understand the underpinnings of IT business value in interorganizational contexts. To the extent alliances are a means of recombining resources to innovate and to quickly enter new product or market spaces, firms should pay attention to the capability of reconfiguring internal firm resources and detect new opportunities for value creation, competencies in which IT has a demonstrably valuable role.

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Appendix. Details Regarding Measures

Coding and Verification of Alliance Attributes
We distinguish among alliances based on the types of activities involved. We define collaborative alliances as those that include any of the following characteristics: (1) sharing of firm-specific or tacit knowledge, such as in joint design or development (Anand and Khanna 2000, Gulati and Singh 1998, Zollo et al. 2002); (2) recombination of products, services, or processes across organizational boundaries (Eisenhardt and Martin 2000, Zollo et al. 2002); or (3) heavy coupling of interorganizational business processes (Gosain et al. 2005, Kim and Mahoney 2006, Zaheer and Venkatraman 1994). Unlike in arm's-length alliances, collaborative alliances involve a great deal of information or knowledge exchange and recombination of knowledge. A summary of arguments is provided in Table A.1. Table A.2 provides a set of examples that illustrate these features of collaboration.

The collaborative alliance examples describe alliance partners working together to develop new products or services, such as the joint competency center between Intentia and Sun Microsystems. The examples also exemplify cooperation involving tacit knowledge and firm-specific assets, such as in the alignment of sales and marketing

Table A.1 Features of Collaborative Alliance Activities

Feature	Description and references
Sharing of firm-specific or tacit knowledge	Collaborative alliances involve not just the exchange of goods and services, but often entail cooperation in the joint design or development of products, services, or information systems (Almeida et al. 2002, Gulati and Singh 1998, Oxley 1997). Tacit or firm-specific exchange of knowledge, such as knowledge sharing typically occurs in joint R&D projects, or in joint software or Internet systems development projects.
Highly coupled and integrated business processes	Coordination-intensive, highly coupled, and integrated business processes that link firms (Afuah 2000; Clark and Stoddard 1996; Dewan et al. 1998; Dyer 1996, 1997; Gosain et al. 2005; Hasselbring 2000; Hitt 1999; Kim and Mahoney 2006; Malhotra et al. 2005; Pavlou and El Sawy 2006).
Reconfiguration or recombination of products, services, or processes	Collaborative alliances are more likely to require reconfiguration, or modification of business processes in the process of alliance formation (Henderson and Clark 1990). They may also involve the recombination of products or services of multiple firms in the creation of a new product or service. Because collaborative alliances involve the integration of business processes of two distinct firms, over the course of the alliance relationship, firms are likely to reconfigure business processes to accommodate changes in business requirements or conditions (Afuah 2000, Eisenhardt and Martin 2000, Teece et al. 1997, Young-Ybarra and Wiersema 1999).

teams between Sprint Corporation and Sun Microsystems. Table A.2 also describes the recombination of Colgate's oral care products with Nestlé's confectionary products to create new combined products that "taste good, clean teeth and freshen breath." All three examples illustrate a relatively high degree of tacit knowledge sharing, coordination, and recombination or reconfiguration of processes.

To identify collaborative and arm's-length alliances, we developed an automated coding procedure to classify alliances as collaborative or arm's-length based on free-text descriptions of alliance activities, adapting methods described by Nag et al. (2007) and Tetlock et al. (2008). Prior alliance typologies have used alliance activity labels, but these do not map consistently to theories of collaboration depth where the emphasis is on business processes. Fortunately, relevant information can be extracted from the alliance descriptions ("deal text") that are in free text form in the SDC Platinum database. Converting such free text into a categorical or quantitative measure for large data sets requires a systematic and automated procedure of content-analysis to ensure consistency, accuracy, and reliability. This procedure involves the following three steps.

First, we evaluated the feasibility of content for analysis and identified a set of representative tokens or keywords.

Table A.2 Examples of Collaborative and Arm's-length Alliances

Collaborative alliances

Example 1: Sprint Corp. (NYSE: FON) and Sun Microsystems (NASDAQ: SUNW) are aligning sales and marketing teams to create a strategic alliance that will provide an integrated Web solution for customers, enabling both companies to capture revenue and market share in the hosting and application infrastructure provider markets. Through this agreement, Sun becomes a preferred technology provider within the Sprint E|Solutions Internet Center infrastructure and will help drive significant sales activity during the next three years.

Example 2: Sun and Intentia formed an alliance in which Intentia will offer e-collaboration software and implementation services on the Sun Solaris Operating Environment. Sun will support Intentia's Movex NextGen in go-to-market activities, implementation, and support processes. Working with Intentia's business consultants, Sun will provide professional services to maximize the performance of NextGen running on Sun systems and engage with Intentia's implementation methodology, Implex. To further enhance the Movex NextGen offering, Sun and Intentia will bring complementary technologies and services to joint customers through a competency center. The competency center will provide a comprehensive set of services to help make the implementation process faster, easier, and safer.

Example 3: Food giant Nestlé SA, whose empire includes chocolates and sugar-sweetened ice tea, is joining with toothpaste maker Colgate-Palmolive to market oral-care products. The plan of the joint venture is to "pursue on a worldwide basis the development, marketing, distribution and sale of a portfolio of portable oral care products" that "taste good, clean teeth and freshen breath." The initial product of the collaboration will be Colgate Dental Gum, in its current test markets in Britain, Ireland, and Canada.

Arm's-length alliances

Example 1: BioProgress PLC (BP) and Wyeth (WT) formed a strategic alliance wherein BP exclusively licensed its XGEL SWALLOW liquid-filled capsule technology to WT. Under terms of the agreement, the alliance provided WT with an exclusive opportunity to evaluate the technology and negotiate terms following upfront payment of a six-figure sum on execution.

Example 2: Formica Corporation has created a strategic alliance with Lowe's Companies, Inc. (NYSE: LOW) of Wilkesboro, North Carolina, the world's second largest home improvement retailer. Lowe's now carries Formica brand laminate sheets, as well as postformed countertops clad with Formica brand laminate, and Formica brand adhesives, beveled edges, sealants, and caulk. Lowe's also offers FormicaTile, Formica Corporation's industry exclusive authentic tile-design surfacing, as well as Surell and Fountainhead solid surfacing material.

Example 3: Quest Diagnostics Incorporated, the nation's leading provider of diagnostic testing, information, and services, and Enterix Inc., a privately held colorectal cancer-screening company, announced that they have entered into an agreement to offer InSure, Enterix's proprietary, FDA-cleared testing procedure and device to detect human hemoglobin. The alliance gives Enterix access to Quest Diagnostics' extensive distribution network and their substantial relationships with physicians.

Source. All of the examples are direct quotes from the "deal text" data column provided in the SDC Platinum database.

The final sample of 169 firms engaged in 3,129 alliances. Using a random number generator, we randomly selected 10% of these alliances, and then retrieved relevant news articles regarding these alliance announcements through searches in Factiva. We verified that the "deal text" description in the SDC database accurately captures the essential activities involved in the alliance by cross-checking with corresponding news articles in Factiva and found very few inaccuracies of description, suggesting that accurate content analysis of deal descriptions in SDC is possible. Using the criteria of prior theory and theory development of this paper, one of the authors completed a preliminary hand coding of the 10% sample of alliances, categorizing each as collaborative or arm's-length based on a careful reading of the given description. In this manual process, it became apparent that certain keywords were consistently suggestive of whether the alliance was collaborative or arm's-length. This was further confirmed by feeding alliance texts into content analysis software (Wordsmith and Catpac) in two separate groups (collaborative and arm's-length alliance descriptions), and observing nonoverlapping sets of keywords emerge from each group. The roots of keywords associated with collaborative alliances are *joint*, *integrate*, *develop*, *cooperate*, *collaborate*, *combine*, *build*, *produce*, *manufacture*, and *design*. Roots of keywords associated with arm's-length alliances are *license*, *terms*, *purchase*, *provide*, *market*, *offer*, *agree*, *exchange*, *sign*, *grant*, *sell*, and *resale*.

Second, we developed and refined simple coding rules for automated coding of alliances as collaborative or arm's-length based on their descriptions. Starting with the keywords, we devised a simple set of rules determining whether certain keywords were to be designated as strong or weak; this was sufficient to resolve ambiguities in some cases where an alliance showed characteristics of both collaboration and arm's-length agreement. To further verify these coding rules, two researchers with substantial relevant industry experience independently replicated the manual coding exercise for a 10% randomly selected portion of the training sample of alliances. Correlations among independent coding responses are highly significant at $p < 0.001$. Having developed and independently verified the coding rules for this randomly selected subset of alliances, we applied the automated coding procedure to the entire set of alliances.

Third, we examined the outcome of automated coding for both sufficient variation in data, robustness of results, and consistency with manual coders. We conducted a confirmatory test of the consistency of the automated coding result with human manual coding based on a different 10% selection of alliance description readings. A two-by-two analysis of variance yielded a χ^2 test statistic that was significant at $p < 0.001$. The alliance type counts are shown in Table A.3, which shows that the automated coding procedure identified 42.5% of the alliances as collaborative and 57.5% of the alliances as arm's-length. Consistent with theory, joint ventures are more likely to be collaborative alliances, whereas nonequity alliances are more likely to be arm's-length alliances (Gulati and Singh 1998, Zollo et al. 2002).

Finally, some basic robustness checks were employed to examine the sensitivity of data and analysis to small changes in these coding rules. We generated added-variable plots on collaborative and arm's-length alliances to identify influential data points and found that neither removal of these data points nor minor alterations in coding rules had any effect on the significance or direction of the main results.

Table A.3 Cross-Sectional Proportions of Alliance Formation Characteristics; Based on 3,129 Alliances Occurring Between 2000–2006 by Firms for Which We Had SOA Measures

	Joint venture (%)	Nonequity (%)	Total (%)
Collaborative	16.8	25.7	42.5
Arm's-length	5.2	52.3	57.5
Total	22.1	77.9	100

Measuring Dimensions of IT Architecture Flexibility

Among IT capabilities, SOA is closely associated with the flexibility-related capabilities of process reconfiguration and opportunity detection (Cherbakov et al. 2005, Prahalad and Krishnan 2008). SOA is a framework comprised of guidelines and principles that enable greater ease of change, modularity, and transparency of business processes (Babcock 2007). Each dimension of IT architecture flexibility is measured using the following questions from the *InformationWeek* 2003 survey. Below, we list the pertinent survey question after the description for each dimension. The answer choices for each question are available from the authors. To construct each flexibility dimension measures we used the standardized sum of standardized items for each question. To construct the measure of overall IT architecture flexibility, we used the first principle component across all three dimensions plus a measure for the SOA technology layer.

Open Communication Standards. We measure open communication standards as the extent of use of common data representation language, XML, that is used in SOA (*XML*). XML can be defined simply as a platform-independent metalanguage for storing and transmitting information. XML is the basis for many open standards that enable automated communication. These standards are developed through a rigorous and public process by the leading Internet standards bodies of the World Wide Web Consortium (W3C) or the Organization for the Advancement of Structured Information Standards. XML-based communication standards have been developed to facilitate communication in almost every industry, such as in the petroleum industry exchange (http://xml.coverpages.org/pidx.html), structured product labeling in the pharmaceutical industry (http://www.dclab.com/spl_conversion.asp), and the financial information exchange protocol among many other standards in the financial industry (http://www.fixprotocol.org/). Some standards, such as ebXML, are used in multiple industries such as the automotive, healthcare, and travel industries. Other standards are more horizontal in that they pertain to a general technology medium or function rather than industry-specific business processes; these include standards for voice, mathematical documents, vector graphics, and database queries, among many others (http://www.ibm.com/developerworks/xml/standards/). To measure the extent of use of XML as a proxy for adoption of open communication standards, we count the number of processes in which XML is used, including in website functionality, in data exchanges or transactions with customers or suppliers, in content management, in data or application integration, or in pilot testing/evaluation.

Survey question: How does your organization use XML if at all? (Choose ALL that apply; five choices)

Cross-Functional Transparency. Cross-functional transparency reflects the extent to which electronic interfaces are visible and accessible for use across the organization. We use the breadth of use of Web services as a proxy for cross-functional transparency. Web services are defined simply as a body of "Internet-era standards for exchanging data between applications" (McAfee 2005, p. 78). More precisely, Web services are a specific body of standards developed by the W3C that enable industrywide standards of communication syntax based upon a vendor-neutral communications framework. Web services have become the de facto framework for SOA. The greater the breadth of use of Web services across different functional areas of the firm, the greater the transparency and visibility of capabilities across the firm, and the greater the likelihood that firms will be able to engage or recombine capabilities in collaboration with other firms. We measure breadth of Web-services utilization as the number of organizational goals or functional areas for which Web services have been adopted in the firm.

Survey question: Which of the following goals, if any, constitute your organization's business case for adopting Web-services standards? (Choose ALL that apply; 11 choices)

Modularity. Even in the presence of open communication standards or cross-functional transparency, it would be difficult to reuse, recombine, or leverage these capabilities in the process of creating new functional entities without sufficient modularity made possible by a services-based architecture. In the SOA framework, the basic modular units of functionality are known as services. As a proxy for modular architecture, we consider whether a services-based IT architecture has been widely deployed within the firm.

Survey question: Has your IT department developed and deployed a companywide services-based IT architecture? (Choose ONE only; four choices. This item was first coded as binary, with the value of one for selection of choice a, "Yes, deployed widely," and zero otherwise. The measure was then standardized.)

It is worthwhile to clarify the distinction between the measurement of modularity and cross-functional transparency. By capturing the number of functional areas that are involved in the firm's SOA initiative, the measure of cross-functional transparency is a proxy for the degree of discoverability, or transparency, of digital business services across functional areas. This measure is distinct from modularity, because firms may require all functional areas to participate in a centrally defined IT architecture and to make their services available through that architecture. Although this promotes transparency across functional areas, firms often enforce such transparency without modularizing their digital business services. In practice, this has been an ongoing problem hindering the flexibility of firms with monolithic IT architectures. In contrast to the measure of cross-functional transparency, the measure of modularity pertains to the architecture of the firm's IT systems, and specifically whether the firm has a services-based architecture that is deployed widely in the firm. Sometimes firms deploy a services-based architecture, which enables modularity of its digital business components, but relatively few functional areas participate in the initiative (Brown et al. 2009). Without the wide participation of various functional areas in the SOA initiative, key digital business capabilities remain obscured between functional areas even as the technical means to modularize those components has been put into place. This is a well-known problem of SOA governance that hinders the flexibility of firms to exploit new business opportunities (Brown et al. 2009). One of the key advantages of a comprehensive SOA capability is that it enables firms to benefit from both flexibility and transparency, and not to get mired in the trade-offs between centralized and decentralized systems that have hindered traditional IT architectures in the past.

Alliance Network Controls

Alliance Activity Scope (*Scope*). This control measures the number of cooperative activities per alliance.

International. This control measures the percentage of alliance partners whose corporate headquarters are located in a different nation from that of the focal firm.

Experience with Technology-Based Alliances (*Tech Hist. 3 year*). This control measures the percentage of alliance activities, over the three previous years ($t-4$ to $t-1$), involving the joint development of new technology or technological processes: manufacturing, software development, research and development, Internet, computer integrated systems, telecommunications, communications, and exploration.

Experience with Marketing-Based Alliances (*Mkt Hist. 3 year*). This control measures the percentage of marketing-based alliance activities, over the three previous years ($t-4$ to $t-1$).

Experience with Joint-Venture Alliances (*JV Hist. 3 year*). This control measures the percentage of alliances, formed over the three previous years ($t-4$ to $t-1$), that are joint ventures.

IT Intensity of Partners (*IT Prtnr*). This control measures the industry-level approximation of average IT intensity of business partners, using the most detailed available NAICS codes available for each industry in the Bureau of Economic Analysis (fixed assets consumer durable goods, current cost) data.

Free Cash Flow of Partners (*Cash Prtnr*). This control measures the average free cash flow of alliance partners.

Profitability of Partners (*ROA Prtnr*). This control measures the average return on assets (ROA) of alliance partners. ROA is measured as the operating income (Compustat #13) divided by the total book value of assets (Compustat #6).

Employees of Partners (*Empl Prtnr*). This is the average number of employees of alliance partners.

R&D of Partners (*R&D Partnr*). This is the average R&D expenditure ratios of alliance partners.

Advertising of Partners (*Adv Prtnr*). This is the average advertising expenditure ratios of alliance partners.

Partners per Alliance. This is the average number of partners per alliance formed in the current year.

Same Industry. This control measures the percentage of alliances formed within the same three-digit NAICS code.

Alliance Size. Alliance size is estimated as the focal firm's total capitalized value of alliances, divided by number of alliance partners. To impute missing values, we used a sample of 4,766 alliances from the original data set in which alliance size was specified. This sample was randomly partitioned into a training sample of 60% and validation sample of 40%. A Tobit regression model was estimated using the training sample; the parameters were dummy variables representing alliance activity types, two-digit industry codes, year, and governance type. The resulting model was then tested using the validation sample; the resulting mean standard error of prediction difference was less than 1.5%. This measure is expressed in millions of dollars in summary statistics and rescaled to billions of dollars in regression estimates.

Industry Controls

Industry Concentration (*Herfindahl index*). This variable is given as $\mathbf{\Sigma}_i s_{ij}^2$, where s_{ij} is the market share of firm i in industries j, as in Hou et al. (2006)

Weighted Industry Average Tobin's q (*Industry Tobin's q*). Market share weighted average Tobin's q for all firms with the same three-digit NAICS code.

Weighted Industry Capital Intensity (*Ind. cap. intens.*). The control is the market share weighted average capital intensity, defined in Waring (1996) as physical capital/net income. Physical capital is the book value of physical capital (Compustat #8).

Regulation. This is a binary variable for regulated industries; these include airlines, banking, pharmaceuticals, and utilities.

Firm Controls

Employees. This variable measures the number of employees in the firm, which is a measure of firm size, in thousands.

IT Intensity (IT). This variable measures the percentage of revenue represented by the firm's total worldwide IT budget, from annual *InformationWeek* surveys.

Advertising Intensity (*Advertising*). This variable measures the portion of sales spent on advertising. If this value was missing in Compustat, we used the three-digit NAICS industry average, weighted by the firm's industry segments.

R&D Intensity (*R&D*). This variable measures the portion of sales spent on research and development. If this value was missing in Compustat, we used the three-digit NAICS industry average, weighted by the firm's industry segments.

Weighted Market Share (*Market share*). This variable is given as $\mathbf{\Sigma}_j MS_{ij} P_{ij}$, where MS_{ij} is firm i's market share in three-digit NAICS industry j, and P_{ij} is the portion of the firm i's sales in industry j. The variable P_{ij} is calculated using the Compustat Industrial Segments database.

Related diversification (*Rel. diversification*). This measures is given by $\mathbf{\Sigma} P_t \log(1/P_t) - \Sigma P_u \log(1/P_u)$, as described by Robins et al. (1995), where P_t is the percentage of sales in each four-digit NAICS industry, and P_u is the percentage of sales in each two-digit NAICS category.

References

Afuah A (2000) How much do your co-opetitors' capabilities matter in the face of technological change? *Strategic Management J.* 21(3):387–404.

Almeida P, Song J, Grant RM (2002) Are firms superior to alliances and markets? An empirical test of cross-border knowledge building. *Organ. Sci.* 13(2):147–161.

Anand BN, Khanna T (2000) Do firms learn to create value? The case of alliances. *Strategic Management J.* 21(3):285–315.

Anderson TW (1984) *Introduction to Multivariate Statistical Analysis*, 2nd ed. (John Wiley & Sons, New York).

Babcock C (2007) BearingPoint says SOA can be costly, hard to maintain. *InformationWeek* (April 27), http://www.informationweek.com/bearingpoint-says-soa-can-be-costly-hard/199202015.

Baldwin CY, Clark KB (2000) *Design Rules: The Power of Modularity* (MIT Press, Cambridge, MA).

Barua A, Lee B (1997) An economic analysis of the introduction of an electronic data interchange system. *Inform. Systems Res.* 8(4):398–422.

Bharadwaj A, Bharadwaj S, Konsynski BR (1999) Information technology effects on firm performance as measured by Tobin's *q*. *Management Sci.* 45(7):1008–1024.

Black SE, Lynch LM (2001) How to compete: The impact of workplace practices and information technology on productivity. *Rev. Econom. Statist.* 83(3):434–445.

Brown WA, Laird RG, Gee C, Mitra T (2009) *SOA Governance: Achieving and Sustaining Business and IT Agility* (IBM Press Pearson Plc, Boston).

Brynjolfsson E, Hitt LM, Yang S (2002) Intangible assets: Computers and organizational capital. *Brookings Papers Econom. Activity* 2002(1):137–199.

Brynjolfsson E, Malone TW, Gurbaxani V, Kambil A (1994) Does information technology lead to smaller firms? *Management Sci.* 40(12):1628–1644.

Burgelman RA, McKinney W (2006) Managing the strategic dynamics of acquisition integration: Lessons from HP and Compaq. *California Management Rev.* 48(3):6–27.

Byrd TA, Turner DE (2000) Measuring the flexibility of information technology infrastructure: Exploratory analysis of a construct. *J. Management Inform. Systems* 17(1):167–208.

Chan SH, Kensinger JW, Keown AJ (1997) Do strategic alliances create value? *J. Financial Econom.* 46(2):199–221.

Chari MDR, Devaraj S, David P (2008) The impact of information technology investments and diversification strategies on firm performance. *Management Sci.* 54(1):224–234.

Chatterjee D, Segars AH, Watson RT (2006) Realizing the promise of e-business: Developing and leveraging electronic partnering options. *California Management Rev.* 48(4):60–83.

Cherbakov L, Galambos G, Harishankar R, Kalyana S, Rackham G (2005) Impact of service orientation at the business level. *IBM Systems J.* 44(4):653–667.

Cisco Systems (2008) Renault and Nissan: Forging a global alliance that is greater than the sum of its parts. Report, Cisco Systems, San Jose, CA. Accessed March 10, 2008, http://blog.lib.umn.edu/devau002/mgmt6033001/2008/02/renault_and_nissan_forging_a_g.html.

Clark TH, Stoddard DB (1996) Interorganizational business process redesign: Merging technological and process innovation. *J. Management Inform. Systems* 13(2):9–28.

Clemons E, Reddi S, Row M (1993) The impact of information technology on the organization of economic activity: The "move to the middle" hypothesis. *J. Management Inform. Systems* 9(2):9–28.

Dewan S, Michael SS, Min CK (1998) Firm characteristics and investments in information technology: Scale and scope effects. *Inform. Systems Res.* 9(3):219–232.

Duncan NB (1995) Capturing flexibility of information technology infrastructure: A study of resource characteristics and their measure. *J. Management Inform. Systems* 12(2):37–58.

Dyer JH (1996) Specialized supplier networks as a source of competitive advantage: Evidence from the auto industry. *Strategic Management J.* 17(4):271–292.

Dyer JH (1997) Effective interfirm collaboration: How firms minimize transaction costs and maximize transaction value. *Strategic Management J.* 18(7):535–556.

Eisenhardt KM, Martin JA (2000) Dynamic capabilities: What are they? *Strategic Management J.* 21(10–11):1105–1121.

Erl T (2007) *SOA Principles of Service Design* (Prentice Hall, Boston).

Ethiraj SK, Levinthal D (2004) Modularity and innovation in complex systems. *Management Sci.* 50(2):159–173.

Galunic DC, Rodan S (1998) Resource recombinations in the firm: Knowledge structures and the potential for Schumpeterian innovation. *Strategic Management J.* 19(12):1193–1201.

Gomes-Casseres B (2005) Outsource processes, don't abandon them *CIO Magazine* (October 1), http://www.cio.com/article/print/12556.

Gosain S, Malhotra A, El Sawy OA (2005) Coordinating for flexibility in e-business supply chains. *J. Management Inform. Systems* 21(3):7–45.

Greene WH (2003) *Econometric Analysis*, 5th ed. (Prentice Hall, Upper Saddle River, NJ).

Gulati R (1998) Alliances and networks. *Strategic Management J.* 19(4):293–317.

Gulati R (1999) Network location and learning: The influence of network resources and firm capabilities on alliance formation. *Strategic Management J.* 20(5):397–420.

Gulati R, Singh H (1998) The architecture of cooperation: Managing coordination costs and appropriation concerns in strategic alliances. *Admin. Sci. Quart.* 43(4):781–814.

Hagel J, Brown JS (2001) Your next IT strategy. *Harvard Bus. Rev.* 79(10):105–113.

Hasselbring W (2000) Information system integration. *Communications of the ACM* 43(6):32–38.

Henderson RM, Clark KB (1990) Architectural innovation: The reconfiguration of existing product technologies and the failure of established firms. *Strategic Management J.* 35(1):9–30.

Hitt LM (1999) Information technology and firm boundaries: Evidence from panel data. *Inform. Systems Res.* 10(2):134–149.

Hou K, Robinson DT (2006) Industry concentration and average stock returns. *J. Finance* 61(4):1927–1956.

Inkpen AC (2008) Knowledge transfer and international joint ventures: The case of Nummi and General Motors. *Strategic Management J.* 29(4):447–453.

Inkpen AC, Currall SC (2004) The coevolution of trust, control, and learning in joint ventures. *Organ. Sci.* 15(5):586–599.

Jarvis CB, Mackenzie SB, Podsakoff PM (2003) A critical review of construct indicators and measurement model misspecification in marketing and consumer research. *J. Consumer Res.* 30(2):199–218.

Kale P, Dyer JH, Singh H (2002) Alliance capability, stock market response, and long-term alliance success: The role of the alliance function. *Strategic Management J.* 23(8):747–767.

Kim SM, Mahoney JT (2006) Mutual commitment to support exchange: Relation-specific IT system as a substitute for managerial hierarchy. *Strategic Management J.* 27(5):401–423.

Lavie D (2007) Alliance portfolios and firm performance: A study of value creation and appropriation in the U.S. software industry. *Strategic Management J.* 28(12):1187–1212.

Malhotra A, Gosain S, El Sawy OA (2005) Absorptive capacity configurations in supply chains: Gearing for partner-enabled market knowledge creation. *MIS Quart.* 29(1):145–187.

McAfee A (2005) Will web services really transform collaboration? *MIT Sloan Management Rev.* 46(2):78–84.

Mega International (2004) Evolving companies may control their information system. Report, Mega International, Raynham, MA. Accessed August 9, 2012, http://www.cxo.eu.com/article/Evolving-companies-may-control-their-information-system/.

Mithas S, Jones JL (2007) Do auction parameters affect buyer surplus in e-auctions for procurement? *Production Oper. Management* 16(4):455–470.

Mithas S, Krishnan MS (2009) From association to causation via a potential outcomes approach. *Inform. Systems Res.* 20(2): 295–313.

Mithas S, Whitaker J (2007) Is the world flat or spiky? Information intensity, skills, and global service disaggregation. *Inform. Systems Res.* 18(3):237–259.

Mithas S, Jones JL, Mitchell W (2008) Buyer intention to use Internet-enabled reverse auctions: The role of asset specificity, product specialization, and non-contractibility. *MIS Quart.* 32(4):705–724.

Mithas S, Tafti A, Bardhan I, Goh JM (2012) Information technology and firm profitability: Mechanisms and empirical evidence. *MIS Quart.* 36(1):205–224.

Moore SA (2001) A foundation for flexible automated electronic communication. *Inform. Systems Res.* 12(1):34–62.

Nag R, Hambrick DC, Chen MJ (2007) What is strategic management, really? Inductive derivation of a consensus definition of the field. *Strategic Management J.* 28(9):935–955.

Natis YV, Schulte RW (2003) Introduction to service-oriented architecture. Research note SPA-19-5971, Gartner, Stamford, CT.

Nijman T, Verbeek M (1992) Nonresponse in panel data: The impact on estimates of a life cycle consumption function. *J. Appl. Econometrics* 7(3):243–257.

Orton JD, Weick KE (1990) Loosely coupled systems: A reconceptualization. *Acad. Management Rev.* 15(2):203–223.

Oxley JE (1997) Appropriability hazards and governance in strategic alliances: A transaction cost approach. *J. Law, Econom. Organ.* 13(2):387–409.

Pavlou P, El Sawy O (2006) From IT leveraging competence to competitive advantage in turbulent environments: The case of new product development. *Inform. Systems Res.* 17(3):198–227.

Prahalad CK, Krishnan MS (2008) *The New Age of Innovation: Driving Cocreated Value Through Global Networks* (McGraw-Hill, New York).

Rai A, Patnayakuni R, Patnayakuni N (1997) Technology investment and business performance. *Commun. ACM* 40(7):89–97.

Rai A, Patnayakuni R, Seth N (2006) Firm performance impacts of digitally enabled supply chain integration capabilities. *MIS Quart.* 30(2):225–246.

Ray G, Wu D, Konana P (2009) Competitive environment and the relationship between IT and vertical integration. *Inform. Systems Res.* 20(4):585–603.

Robins J, Wiersema M (1995) A resource-based approach to the multibusiness firm: Empirical analysis of portfolio interrelationships and corporate financial performance. *Strategic Management J.* 16(4):277–299.

Sahaym A, Steensma HK, Schilling MA (2007) The influence of information technology on the use of loosely coupled organizational forms: An industry-level analysis. *Organ. Sci.* 18(5): 865–880.

Sambamurthy V, Bharadwaj A, Grover V (2003) Shaping agility through digital options: Reconceptualizing the role of information technology in contemporary firms. *MIS Quart.* 27(2): 237–263.

Sanchez R, Mahoney JT (1996) Modularity, flexibility, and knowledge management in product and organization design. *Strategic Management J.* 17(1):63–76.

Schilling MA (2009) Understanding the alliance data. *Strategic Management J.* 30(3):233–260.

Schilling MA, Phelps CC (2007) Interfirm collaboration networks: The impact of large-scale network structure on firm innovation. *Management Sci.* 53(7):1113–1126.

Srinivasan K, Kekre S, Mukhopadhyay T (1994) Impact of electronic data interchange technology on JIT shipments. *Management Sci.* 40(10):1291–1304.

Teece DJ, Pisano G, Shuen A (1997) Dynamic capabilities and strategic management. *Strategic Management J.* 18(7):509–533.

Tetlock PC, Saar-Tsechansky M, Macskassy S (2008) More than words: Quantifying language to measure firms' fundamentals. *J. Finance* 63(3):1437–1467.

Venkatraman N (1994) IT-enabled business transformation: From automation to business scope redefinition. *Sloan Management Rev.* 35(2):73–87.

Waring GF (1996) Industry difference in the persistence of firm-specific returns. *Amer. Econom. Rev.* 86(5):1253–1265.

Williamson OE (1981) The economics of organization: The transaction cost approach. *Amer. J. Sociol.* 87(3):548–577.

Williamson OE (1983) Credible commitments: Using hostages to support exchange. *Amer. Econom. Rev.* 73(4):519–540.

Wooldridge JM (2002) *Econometric Analysis of Cross Section and Panel Data* (MIT Press, Cambridge, MA).

Wooldridge JM (2005) Simple solutions to the initial conditions problem in dynamic, nonlinear panel data models with unobserved heterogeneity. *J. Appl. Econometrics* 20(1):39–54.

Young-Ybarra C, Wiersema M (1999) Strategic flexibility in information technology alliances: The influence of transaction cost economics and social exchange theory. *Organ. Sci.* 10(4):439–459.

Zaheer A, Venkatraman N (1994) Determinants of electronic integration in the insurance industry: An empirical test. *Management Sci.* 40(5):549–566.

Zhu K, Kraemer KL, Gurbaxani V, Xin Xu S (2006) Migration to open-standard interorganizational systems: Network effects, switching costs, and path dependency. *MIS Quart.* 30(Special Issue):515–539.

Zollo M, Reuer JJ, Singh H (2002) Interorganizational routines and performance in strategic alliances. *Organ. Sci.* 13(6):701–713.