Dynamic Capabilities in the Firm-Value Effects of Strategic Alliances: The Influence of Information Technology and Service-Oriented Architectures

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Although strategic alliances and information technology (IT) have become central components of firm strategy, there has been to date no empirical examination of the firm-performance effects of IT investment in the context of strategic alliances. We argue that IT and service-oriented architectures (SOA) are likely to create value through enhanced dynamic capabilities of resource configuration and opportunity detection. We test our theoretical framework by examining the influence of IT investment and flexible IT infrastructure, through SOA, in the effect of alliance activity on firm performance. We utilize data from 375 firms that are publicly listed in the United States and that span multiple industries. These firms have collectively engaged in more than 8,000 alliances over a period of 10 years. We find that the contribution of joint ventures to firm value increases with investment in IT and in SOA. We also find that the impacts of IT and SOA are greater in the case of joint ventures than in non-equity alliances.

Key words: Information Technology, Service-Oriented Architecture, Alliances, Intangible Value, Business Value of IT, Dynamic Capabilities

1. Introduction

Why do firms differ in the value that they derive from inter-firm alliances? To answer this question we consider the role of information technology (IT), which has transformed the way organizations collaborate. In the Information Systems literature, the study of the role of IT in inter-organizational relationships has primarily emphasized efficiency and accuracy of transactions in existing supply chains (Barua and Lee 1997; Hitt 1999; Mukhopadhyay and Kekre 2002; Rai, Patnayakuni and Seth 2006). In the Strategic Management literature, alliances have been examined as capabilities in themselves, without consideration of the investments in business process infrastructure that underlie such capabilities (Gulati 1999; Kale, Dyer and Singh 2002; Lavie 2007; Zollo, Reuer and Singh 2002). The intersection of these traditions of academic research leaves a substantial gap in our understanding of the *internal* capabilities required for firms to derive value from their collaborative alliances.

Collaborative alliances are defined as "voluntary arrangements between firms involving exchange, sharing, or co-development of products, technologies, or services" (Gulati 1998 p. 293). In the formation of collaborative alliances, we argue that the impending challenges are not only to optimize the efficiency or accuracy of transactions, but also to codify and mobilize tacit knowledge, and to reconfigure processes for the creation of new boundary-spanning processes. The contrast between the recent experiences of General Motors (GM) and Nissan illustrate these aspects of collaborative alliances. GM lost over $2.4 billion in lost initial investments and an additional $2 billion in settlement costs as a result of a failed joint venture with Fiat that dissolved primarily because of GM's difficulties in transferring managerial and technological capabilities to leverage joint business processes (Gomes-Casseres 2005). In contrast, Nissan has been able to derive greater value from its joint venture with Renault, in part because Nissan was able to reconfigure its processes to leverage greater synergies in the joint venture through investments in IT (CXO 2004; Gomes-Casseres 2005; Renault 2008).

In the context of joint ventures– which are inter-firm collaborations involving bi-lateral investments in equity, hierarchical controls, and reconfiguration of firm resources– we argue that IT can create value by enabling the transformation of firm processes and resources. We discuss two types of IT-enabled transformative, or *dynamic*, capabilities: process reconfiguration and opportunity detection (Sambamurthy, Bharadwaj and Grover 2003; Teece, Pisano and Shuen 1997). First, the digitization of business processes in which products are developed, manufactured, or delivered can enhance the flexibility to reconfigure business processes. Second, digitization of business processes can enhance their transparency and visibility, enabling more effective search and detection of new opportunities for value-creation in joint ventures. Zollo et al. (2002) argue that some partner-specific routines are of greater importance in non-equity alliances than in joint ventures. In contrast, the dynamic capabilities of reconfiguration and opportunity-detection have a greater role in the context of joint-venture alliances than in non-equity alliances (Anand and Khanna 2000; Gulati and Singh 1998; Inkpen 2008). For this reason, the relative firm-performance effects of IT investment in joint-ventures versus non-equity alliances has implications for the enabling role of IT in dynamic capabilities– that is, a role other than reduction of transaction and coordination costs.

While IT investments in aggregate may enable dynamic capabilities of reconfiguration and opportunity detection, it is useful to consider the effect of specific technology frameworks or architectures known to facilitate process reconfiguration and transparency of business processes. One such technology framework is referred to as service-oriented architecture (SOA). SOA is not a single technology or component of technology that can be purchased or installed, but rather, a framework comprised of guidelines and principles that has generated much interest of late for its role in enhancing flexibility, modularity, and transparency of business processes (Natis and Schulte 2003). The capabilities and routines required for a firm's competency in SOA are suggestive of dynamic capabilities according to the criteria presented in prior literature because they facilitate transformation (reconfiguration and opportunity detection), they take time to develop, and once developed, can be invoked with a degree of reliability (Winter 2003; Zollo and Winter 2002).

Despite the importance of IT in an increasingly networked economy, to our knowledge the quantitative economic impacts of IT have not been examined in the context of strategic alliances or joint ventures. We examine whether the effect of collaborative alliance activity on firm performance increases with IT investment, and with capabilities in service-oriented architecture (SOA). In addition, we examine whether the effects of IT investments are greater in the case of joint ventures or in non-equity alliances. While prior research has emphasized the role of IT in the reduction of transaction and coordination costs, we argue that dynamic capabilities are another means by which IT creates value, and that they become particularly salient in the context of joint ventures. We use data from a panel of over 370 firms that are publicly listed in the United States and that span multiple industries; these firms have collectively engaged in more than 8,000 documented alliances over a period of 10 years from 1996-2006.

2. Theoretical Framework

In classical theories of the firm, alliances have drawn special interest because they represent a continuum of hybrid forms between markets and hierarchies (Gibbons 2005). Researchers have considered two broad categories of costs and risks associated with any inter-organization relationship: transaction costs and coordination costs. Transaction costs arise because alliances involve self-interested agents acting opportunistically (Kim and Mahoney 2006), while coordination costs stem from the complexities inherent in coordinating a set of disaggregated processes across firm boundaries (Brynjolfsson, Malone, Gurbaxani and Kambil 1994; Gurbaxani and Whang 1991). To mitigate transaction and coordination costs, partners may decide to include certain hierarchical controls into the alliance (Gulati and Singh 1998). Short of outright integration via a merger, firms may decide to share the risks bilaterally through joint equity investments in a new entity, and thereby, form a joint venture. Mapping the typology of markets and hierarchies to strategic alliances, researchers have argued that joint ventures resemble hierarchies while licensing agreements and other non-equity alliances resemble arms-length market transactions (Gulati and Singh 1998; Oxley 1997).

Prior theory does not provide a clear theoretical resolution of the relative effects of IT in the case of joint ventures as compared to non-equity strategic alliances. On one hand, IT can reduce transaction and coordination costs (Gurbaxani and Whang 1991). Prior research suggests that the effect of IT on external coordination has been greater than the effect on internal coordination; and that IT has brought about an inward shift in the efficient boundary of the firm (Brynjolfsson et al. 1994; Dewan, Michael and Min 1998; Hitt 1999). Based on transaction and coordination costs alone, the implication may be that IT investment will have a smaller effect in joint ventures than in arms-length alliances. On the other hand, IT can enhance capabilities for reconfiguration and detection of opportunities for value creation. Reconfiguration costs are high in the case of joint ventures because they involve a greater bilateral sharing of resources and integration of processes than in arms-length alliances governed by licensing contracts (Gulati and Singh 1998). In addition, IT can enhance the visibility and transparency of business processes, particularly in contexts such as joint ventures which involve a highly tacit form of knowledge exchange. Hence, the relative impact of IT in joint ventures versus in non-equity alliances has implications for the role of IT beyond reduction of transaction and coordination costs.

2.1 Business Value Impacts of Information Technology in Joint Ventures

While there has been extensive discussion in prior research on the impact of IT on transaction and coordination costs, the Dynamic Capabilities perspective suggests additional mechanisms for the enabling role of IT in multi-firm contexts such as joint ventures (Pavlou and El Sawy 2006; Sambamurthy et al. 2003). Teece et al. (1997 p. 516) define dynamic capabilities as “the firm’s ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments”. Through dynamic capabilities, firms develop the capacity to make better strategic decisions, to develop new products, and to derive value from alliances (Eisenhardt and Martin 2000). Drawing upon the Dynamic Capabilities perspective (Eisenhardt and Martin 2000; Teece et al. 1997), we posit that IT can enhance value through two capabilities which are salient in the context of joint ventures: the reconfiguration of processes, and the detection of opportunities for value creation.

First, through the digitization of business processes, IT can reduce the costs associated with reconfiguration of internal firm processes (Allen and Boynton 1991; Byrd and Turner 2000;

Duncan 1995), thereby enabling firms to create synergies in joint ventures. The joint venture between Hershey and Godrej, the Indian confectionary, was made possible in part because Hershey had invested significantly to overcome costly IT-related supply chain problems in the 1990's, and was able to transform its global supply chain operations and make them more flexible (Godrej 2007; Reuters 2007). Hershey integrated its supply chain on a global scale through decision support systems integrated with centralized enterprise systems, and through robotic palletizers at its remote packaging facilities that adjust automatically to new product specifications with minimal disruption (Mans 2008; Reuters 2007). Supply chain flexibility enabled Hershey to form a broader nexus of global partnerships, and to expand the reach of its products and processes without overwhelming its supply capabilities. The ability to configure business processes enables firms to more effectively form new boundary spanning processes (Gosain, Malhotra and El Sawy 2005), and hence, to better capitalize on synergies with joint venture partners.

Second, by enhancing the accessibility of information and the visibility of business processes, IT can enhance firms' capabilities to search and detect new opportunities for innovation in the context of joint ventures (Prahalad and Krishnan 2008). Detection of opportunities for innovation can become costly because of enormous complexity in business processes, wherein firm-specific knowledge of routines is often tacit (Zollo and Winter 2002). By increasing the visibility, transparency, and codifiability of knowledge, investments in IT can enhance "entrepreneurial alertness", and enable firms to extend existing assets to new contexts (Sambamurthy et al. 2003). For example, State Street's foreign currency platform FX Connect and Sungard's eTreasury exchange had distinct contexts of use and well-defined interfaces, under which the details and complexity underlying their functionality were hidden to all but the most familiar technical staff. In combining these systems through an alliance, the firms had to open the black box of their processes and to create entirely new linkages that leveraged the synergies between their product offerings (Sisk 2003).

For a focal firm engaging in a portfolio of alliances, we consider how investments in IT may influence the contribution of joint ventures to firm value. Through enhanced capabilities in process reconfiguration and discovery, IT investment should have a positive influence on the value derived from the joint ventures. IT-enabled dynamic capabilities can enhance a firm's ability to utilize joint ventures to create new products or services (Pavlou and El Sawy 2006), achieve greater reach into new geographical markets, and obtain new market positioning (Sambamurthy et al. 2003). These may not immediately be reflected in accounting measures such as sales, though they are valued by market investors (Anand and Khanna 2000; Chan, Kensinger and Keown 1997). Prior studies have argued for the use of firm-value based constructs in studying the performance impacts of investments in IT (Bharadwaj, Bharadwaj and Konsynski 1999; Brynjolfsson, Hitt and Yang 2002). Forward looking constructs such as firm value are not as vulnerable to changes or idiosyncrasies of accounting practice as are accounting-based measures. Therefore, we hypothesize:

Hypothesis 1: IT intensity positively moderates the effect of joint ventures on firm value.

2.2 Business Value Effects of Service-Oriented Architectures in Joint Ventures

Among IT capabilities, SOA is closely associated with the dynamic capabilities of process reconfiguration and opportunity detection (Cherbakov, Galambos, Harishankar, Kalyana and Rackham 2005; Prahalad and Krishnan 2008). SOA is a framework comprised of guidelines and principles that enable greater flexibility, modularity, and transparency of business processes (Babcock 2007). SOA-related capabilities are likely to develop slowly and over multiple years; as many firms with this broad strategic orientation would utilize earlier incarnations of SOA technologies that emerged in the mid to late 1990's, including object-oriented technologies and service-based component architectures such as CORBA and Java Beans (Natis and Schulte 2003).

SOA does not represent a single technology or component of technology that can be purchased or installed, but rather, is a unifying framework of guidelines and principles under which multiple technologies have emerged and matured to enhance capabilities for process reconfiguration and opportunity detection.

SOA enhances the flexibility and modularity of business processes, which lower the costs of their reconfiguration. Two aspects of SOA capability are particularly relevant to process reconfiguration. First, the existence of a *services-based architecture* enables functional areas of an enterprise to be conceived as modular components that respond to individual service requests. This allows components of a business to be designed with 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). Second, the use of a common data representation language, known as *eXtensible Markup Language (XML)*, enables messaging routines between functional components of the enterprise to be reconfigured at minimal cost. Together, services-based architecture and XML, which enable modularity of enterprise functions and standardization of messaging routines, embody the principles of flexible IS design (Duncan 1995; Gosain et al. 2005; Natis and Schulte 2003). Hence, SOA can facilitate greater agility and flexibility in the establishment of new inter-organizational process linkages without sacrificing the efficiency of these channels (Chatterjee, Segars and Watson 2006; McAfee 2005).

SOA enhances the transparency and visibility of business processes, in turn enhancing the possibilities for detection of new business opportunities in the context of joint ventures. Two aspects of SOA capability are particularly relevant to opportunity-detection. First, the use of technical standards that comprise an ‘enabling layer’ referred to as *web services* provide XML-ready interfaces with external or internal enterprise functions (McAfee 2005). Web services help establish a common grammar in the technical specification of application programmer interfaces (API’s), reducing their context-specificity. This enables the firm to turn tacit knowledge into codified knowledge, mobilize it, and re-apply it to new contexts; increasing the likelihood of detecting value-creating opportunities in joint ventures (Jacobides and Winter 2005; Teece et al. 1997; Zollo and Winter 2002). Second, the *breadth of enterprise functionality in which SOA is used* reflects the level of priority and progress that the firm has made with respect to its SOA capabilities, in alignment with strategic flexibility objectives. This indicates the extent to which the visibility and transparency of business processes enabled by SOA extends across multiple functional areas.

For a focal firm engaging in a portfolio of alliances, we consider how capabilities in SOA may influence the contribution of joint ventures to firm value. Joint ventures involve the sharing of tacit knowledge (Gulati and Singh 1998). Tacit routines or knowledge, while high in the *potential* for novel innovations and value creation, reduce the likelihood of *detection* of opportunities for innovation, and increase the costs of exchange of knowledge resources (Galunic and Rodan 1998). Opportunities may be lost when valuable process knowledge becomes fixed and inseparable from contexts in which a knowledge-base of routines remains highly tacit (Galunic and Rodan 1998; Inkpen and Currall 2004). As standardized interfaces and the modularization of enterprise functions make business processes more explicit and well-defined, knowledge becomes more codified and less tacit. SOA can enhance a firm's capacity for *architectural innovation*, along the lines described by Henderson and Clark (1990), in that firms must alter how the individual components of an enterprise relate to one another as they reconfigure processes to leverage potential inter-firm synergies in a joint venture. Beyond the performance impacts of overall IT infrastructure capability, SOA can bring specific dynamic capabilities of process reconfiguration and opportunity detection that enable firms to further leverage value from joint ventures. Therefore, we hypothesize:

Hypothesis 2: SOA positively moderates the effect of joint ventures on firm value.

2.3 Comparative Effects of IT in Joint Ventures versus Non-equity Alliances

In contrast to alliances governed by licensing agreements or non-equity contracts, joint ventures are equity-based alliances involving bilateral investments in capital, technology, and firm-specific assets. Prior evidence suggests that joint ventures tend to be formed more often in cooperation involving risky projects in which coordination is intrinsically difficult, such as the joint development of new technology (Gulati and Singh 1998; Oxley 1997). The reason is that the bilateral sharing of equity in joint ventures creates an incentive for business partners to monitor each other, and to share information through informal and formal channels. Joint ventures involve the establishment of hierarchical controls to facilitate coordination and to reduce the hazards of partner opportunism. Such hierarchical controls include monitoring systems, command structures, operating protocols, and procedures for dispute resolution (Gulati and Singh 1998). Establishing them requires new information-processing routines and reconfiguration of existing firm processes. As firms transfer firm-specific capabilities and integrate them into a new economic entity to establish a greater flow of information and knowledge, joint ventures require a more drastic reconfiguration of business processes than do alliances that resemble arms-length market transactions.

IT investment can reduce the costs of reconfiguration required in the formation of joint ventures. By increasing the accessibility of information and visibility of business processes, IT can enable firms to detect opportunities for innovation and to reduce the costs of resource recombination, increasing the value that can be derived from joint ventures. Zollo et al. (2002) argue that the formal coordination and monitoring mechanisms provided by joint ventures act as substitute mechanisms, offsetting the transaction and coordination costs inherent in cooperative activities. However, no quantitative empirical tests have been done using objective non-perceptual measures, and hence, whether the costs of transaction or coordination upon which IT has an impact are greater in the case of joint ventures than in non-equity alliances remains unknown. There is reason to believe that it can be costly to reconfigure the processes of the firm in transformation, evolution, and adaptation when new hierarchical arrangements are formed (Oxley 1997); and it is here that we posit an additional contribution of IT to joint venture value. Since the costs of reconfiguration are higher in the case of joint ventures than in arms-length alliances, we argue that the impact of IT will be greater in the case of joint venture alliances than in arms-length alliances.

Hypothesis 3a: The influence of IT intensity on the relationship between alliances and firm value is greater in joint ventures than in non-equity alliances.

The mobilization of firm assets can be particularly difficult in the case of joint ventures, which are more likely than arms-length alliances to involve assets that are firm-specific. Firm-specific processes develop in distinct contexts and lack external interfaces, as the details and complexity underlying firm processes can be hidden to all but the most familiar staff (Henderson and Clark 1990). In combining firm-specific resources, firms have to open the black box of their processes and to create entirely new linkages that leverage inter-firm synergies. An important benefit of SOA is that it allows components of business processes to be invoked by new services without needing to be rebuilt. This allows firms to develop new business models, to modify business processes, and to open new interfaces to existing routines without compromising the security, reliability, and integrity of their pre-existing processes.

Building on the same logic as above, SOA should have a greater impact in the value of joint ventures than in arms-length alliances, because flexibility in mitigating the costs of reconfiguration becomes particularly important in joint ventures. If this is the case, the impact of SOA on the value of joint ventures will be greater even after controlling for IT investment.

Hypothesis 3b: The influence of SOA on the relationship between alliances and firm value is greater in joint ventures than in non-equity alliances.

3. Research Design and Methodology

3.1 Data

The data for this study comes from several sources. First, we obtained the data related to IT investment from *InformationWeek* (IWeek) surveys from 1999 to 2006. InformationWeek surveys are considered to be reliable and have been used in prior academic studies (Bharadwaj et al. 1999; Rai, Patnayakuni and Patnayakuni 1997). Respondents are Chief Information Officers, Chief Technology Officers, or other most senior-level IT executives in the firm: those in the best position to be knowledgeable of firm IT investment figures and IT practices. IT investment is reported as a percentage of firm revenue. Although different firms are included in the IWeek sample in each year, a given firm is present for an average of three out of the seven years. The final sample includes firms from 63 different industries on the 3-digit NAICS level.

Data on several SOA practices were available in the IWeek survey of year 2003. While it is possible that firms' utilization of SOA practices varied over the time of the panel, the technology and business practices that comprise SOA are reflective of a broader set of practices that create the conditions for flexibility in IT infrastructure (Natis and Schulte 2003).[1] Such practices would have developed slowly and over at least a multiple number of years. Hence, a panel from 2000-2006 is short enough that we can reasonably assume that the flexible IT infrastructure practices are constant over this period while it is long enough to correct for potential heterogeneity in unobserved firm fixed-effects.[2] To check this assumption, we used different windows of time in estimation models as a check for robustness.

Second, for publicly listed and identifiable firms in the IWeek sample, we retrieved 2,005 announcements of joint ventures between 1996 and 2006, as well an additional 6,673 announcements of other non-equity alliances, from the SDC Platinum Database (a product of The

1 In fact, earlier incarnations of SOA technologies began to become widely known in the mid to late 1990's, with the emergence of XML and service-based component architectures such as CORBA and Java Beans, and it is likely that many of the firms that reported engaging in SOA practices began in earlier years to develop flexible IT practices around those earlier incarnations of SOA technology.
2 This consideration has also been made in prior panel data studies involving a construct measured at a single point of time, such as in Black and Lynch (2001).

Thomson Corporation). Alliance announcements originate from publicly available sources such as trade publications, SEC filings, and news and wire sources. 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). Alliance records in the SDC Database included dates, deal type, description, names and industry codes of all participating firms, a listing of activities involved in the alliance, and a flag indicating whether the alliance is a joint venture. Of the 2,005 total joint ventures in our sample, 98 (less than 5%) of them involved two or more firms in our sample. Of the remaining 6,673 alliances, 493 (about 7%) involved two or more firms in the sample. The rest involved an alliance between an in-sample focal firm, for which we had IWeek data, and out-of-sample partners for which we had no firm level data on IT investment, or SOA 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.[3]

Third, we retrieved performance variables, as well as firm-level and industry-level controls from the Compustat North America database. The final sample size included 375 firms and 1156 firm-year observations in the unbalanced panel dataset of firms present in at least one of the *InformationWeek* (IWeek) surveys from 1999 to 2006. Of the 375 firms, 177 of them were present in the IWeek 2003 survey in which detailed questions regarding practices that support

3 In comparison to their industry averages of publicly listed firms, the firms in our sample are larger, with approximately three and a half times the number of employees. These firms also have lower R&D investment intensities (6.6% vs. 20% of revenue), lower advertising intensities (4.9% vs. 6.3%), and lower Tobin's q than their industry averages (1.46 vs. 1.96). In relation to their alliance partners, firms in our sample are smaller in terms of the number of employees (37.8 vs. 41.7 thousand), have smaller R&D intensity (6.6% vs. 7.7%), and larger advertising intensities (4.9% vs. 2.9%). Regarding IT-intensity, our data allows only comparison with out-of-sample firms on industry-level measures of IT from BEA. We find that industry-level IT capital intensities of firms in our sample are lower than those of their alliance partners (19.5% vs. 22.5% of combined hardware, software, and communications-equipment assets divided by total assets), although firm-level IT intensities may be higher than those of alliances partners. A direct comparison between firm-level IWeek figures and the publicly available figures from the Bureau of Economic Analysis (BEA) is not possible because they are in different units: The former presents firm-level IT expenditure ratios while the latter presents industry-level IT capital expenditures. However, we see a positive correlation of 0.27, significant at α=0.01, between firm and industry-level measures from these distinct data sources. Basic firm parameters in our sample (firm size, Tobin's q, advertising intensity, R&D intensity, IT-intensity, and related diversification) are comparable to those in (Bharadwaj et al. 1999).

SOA were asked. In the interest of using as much data as possible, we used the larger panel dataset of 375 firms when testing hypotheses related to IT investment and used the smaller subset of the panel when testing hypotheses related to SOA.

3.2 Variable Definitions

The dependent variable 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, DEBT is long-term debt, and TA is the book value of total assets. MVE is the average of twelve 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.

IT intensity *(IT)* indicates 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 represents overall information-intensity of a firm's operations.

The SOA measure reflects four critical aspects of SOA capability described in the theory section: 1) the deployment of services-based architecture (*SBA*), 2) the use of the common data representation language, called eXtensible Markup Language (XML), that is used in SOA (*XML*), 3) the use of technical standards that comprise an 'enabling layer', referred to as *web services*, on top of which SOA is built (*WebServ*), and 4) the number of business functions for which SOA is used, which proxies for firm-wide breadth of SOA use *(SOA_BREADTH)*. Since each of the components of our summative measure for SOA has a different scale, we standardized the SOA measure components *SBA*, *XML*, *WebServ*, and *SOA_BREADTH* before including them in the summative measure of SOA:

SOA = STD(STD(SBA) + STD(XML) + STD($WebServ$) + STD($SOA\_BREADTH$)).[4]

Following Lavie (2007), alliance network size ($Alliance_s$) is imputed as the number of new alliance partners (joint ventures and non-equity alliances) announced from year *t-2* through year *t*. Joint-venture network size (JV_s) is similarly measured. This approximation of network size has been used in prior studies because there is a lack of comprehensive data on alliance-termination dates (Lavie 2007). To reduce correlations in measurement errors across years, we also consider the number of new joint venture *formation* (JV_f) announcements in the year t. This latter construct more closely captures the challenges of resource recombination and process reconfiguration, because we might expect their influence to be greatest in the immediate months surrounding a joint venture formation. We also counted the annual number of newly formed non-equity alliances, those that are not joint ventures ($Non\text{-}EQ_f$).

Control variables related to the characteristics of firm-alliance portfolios include the percentage of technology-based alliances, percentage of international alliances, and scope of alliance activity. For a limited portion of the sample, we were able to obtain measures of partner characteristics, including number of employees, R&D, advertising, free cash flow, profitability, and industry-average IT investment. All control variables are defined in Appendix 1.

Table 1 shows summary statistics and correlations.

3.3 Estimation Model

To connect the theory with the econometric model, we derive a baseline model of IT business value in Appendix 2 and reconcile it with the model in Bharadwaj (1999). In theory,

[4] The indicators are not necessarily interchangeable and the direction of causality flows from these indicators to the main construct. Hence, according to the criteria in Jarvis, Mackenzie and Podsakoff (2003), these are formative indicators. An unrotated principle components analysis (PCA) reveals that all items comprising the measure of SOA load positively onto the first principle component, with weightings for each of between 0.41 and 0.56. The first principle component is above the 1.0 threshold with a value of 1.7; hence, each item contributes significantly to the SOA measure. As a robustness check, all estimation models were run with the first principle component of SOA in place of our summative measure, and resulted in stronger direction and significance for coefficients involving SOA and its interaction with joint ventures. For the sake of parsimony and consistency with prior studies using linear regression models (as well as two-stage least squares, and GMM techniques), we present estimations using the standardized summative measure of standardized items—also done in Bresnahan, Brynjolfsson and Hitt (2002).

joint ventures create value that is not quantified in the accounting books: intangible inter-organizational resources which can generate future profits through the joint development of new products or services (Anand and Khanna 2000; Chan et al. 1997). Hence, we incorporate JV_s, the size of a firm's network of joint-venture partnerships, into the Tobin's q framework.

$$Q = \beta_o + \beta_{IT} IT + \beta_J JV_s + \mathbf{X_C} \boldsymbol{\beta_C} + \sum_t \beta_t \, year_t + \sum_i \beta_i \, industry_i + u_i + \varepsilon_{i,t} \quad (1)$$

Consistent with Bharadwaj et al. (1999), 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. Consistent with Lavie (2007), the matrix also contains controls for characteristics of the firm's alliance network: the scope of alliance activities, the technological basis of alliance activities, and the percentage of international alliances. Equation (1) also includes year and industry (two-digit NAICS) dummy variables.

Next, we formalize the hypotheses and apply them to the model. Suppose that a firm entering into a joint venture obtains a total net present value of $\hat{\pi}_J$ in net profits generated as a result of the alliance. $\hat{\pi}_J$ is the difference between the strategic benefit B_J of a joint venture and its cost C_J; $\hat{\pi}_J = B_J - C_J$.[5] C_J is comprised of the following: costs of coordination c_J, costs of transaction hazards h_J, and costs of reconfiguration r_J: $C_J = c_J + h_J + r_J$. Prior theory, as discussed above, suggests that IT can have a role in decreasing each component of C_J, which we represent using three monotonically decreasing functions on IT, δ_c, δ_h, and δ_r, such that $0 < \delta_{c,h,r} < 1$.[6] The

[5] The strategic benefit B_J of the joint venture may include potential profits generated by new products or services, reach into new geographical markets, or new market positioning. Consider that B_J will also increase with IT, through enhanced dynamic capabilities such as opportunity detection. For the sake of analytical simplicity, this model considers only the effect on the cost component, where theoretical tensions may exist between Dynamic Capabilities and prior theories on transaction and coordination costs regarding their comparative effects in joint ventures versus non-equity alliances. When the IT investment effects on B_J are also considered, the support for the hypotheses is strengthened even further.

[6] The are many possible forms of such functions; but for the sake of illustration here is an example: Suppose we set $\delta_c = \exp(-\alpha_c IT)$, $\delta_h = \exp(-\alpha_h IT)$, and $\delta_r = \exp(-\alpha_r IT)$, in which there are diminishing returns to IT and differential effects on the three components of costs: $C_J = c\exp(-\alpha_c IT) + h\exp(-\alpha_h IT) + r\exp(-\alpha_r IT) + \alpha_{IT} IT$ such that

net contribution of each joint venture to firm value becomes $\hat{\pi}_J = B_J - (c_J\delta_c + h_J\delta_h + r_J\delta_r + \alpha_{it}\ IT)$.

Hence: $\frac{\partial}{\partial IT}\hat{\pi}_J = -\frac{\partial}{\partial IT}C_J = -(c_J\frac{\partial}{\partial IT}\delta_c + h_J\frac{\partial}{\partial IT}\delta_h + r_J\frac{\partial}{\partial IT}\delta_r + \alpha_{it}) = c_J\hat{\delta}_c + h_J\hat{\delta}_h + r_J\hat{\delta}_r - \alpha_{it}$

where ($c_J\hat{\delta}_c + h_J\hat{\delta}_h + r_J\hat{\delta}_r$) represents the gross marginal contribution of IT investment to the value of the joint venture (noting that the sign of $\frac{\partial}{\partial IT}\delta_{c,h,t}$ is negative), α_{it} represents the marginal cost of IT, and $\frac{\partial}{\partial IT}\hat{\pi}_J$ represents the net change in joint venture value for each unit of IT.

As investment in IT increases, we consider whether a reduction in costs associated with coordination, transaction, and reconfiguration will be greater than all additional IT-related expenses as a result of the alliance (α_{it}). Hence, we model the coefficient β_J as $\beta_J = \beta_{J0} + \beta_1 IT$. The contribution of each joint venture to firm value is $\hat{\pi}_J = \frac{\partial q}{\partial JV_s}$. **Hypothesis 1** states that the influence of IT investment on the value contribution of each joint venture is positive: $\frac{\partial \hat{\pi}_J}{\partial IT} = \frac{\partial}{\partial IT}\frac{\partial q}{\partial JV_s} = \beta_1 > 0$.

Next, we incorporate SOA into the model:

$$Q = \beta_o + \beta_{IT}\ IT + (\beta_{J0} + \beta_1 IT + \beta_2 SOA)\times JV_s + \beta_{SOA}\ SOA + \mathbf{X_C}\,\boldsymbol{\beta_C} + u_i + \varepsilon_{i,t} \quad (2)$$

Hypothesis 2 states $\frac{\partial \hat{\pi}_J}{\partial SOA} = \frac{\partial}{\partial SOA}\frac{\partial q}{\partial JV_s} = \beta_2 > 0$. In order to test Hypotheses 3a and 3b, we included non-equity alliances and their interaction with SOA and IT into the model. If the reconfiguration costs are sufficiently larger in the case of joint ventures ($r_J > r_N$, where subscript *N* stands for non-equity alliances)—controlling for the technological basis of alliances, geographic separation, and the scope of activities involved—then the impact of IT-intensity will

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as IT→ 0, C_J → c + h + r. The marginal influence of IT on alliance value is
$\frac{\partial}{\partial IT}\hat{\pi}_J = c_J\alpha_c \exp(-\alpha_c IT) + h_J\alpha_h \exp(-\alpha_h IT) + r_J\alpha_r \exp(-\alpha_r IT) - \alpha_{IT}$

be greater in the case of joint ventures than in other non-equity alliances. **Hypothesis 3a** can be written as: $\frac{\partial}{\partial IT}\hat{\pi}_J > \frac{\partial}{\partial IT}\hat{\pi}_N > 0$. **Hypothesis 3b** states: $\frac{\partial}{\partial SOA}\hat{\pi}_J > \frac{\partial}{\partial SOA}\hat{\pi}_N > 0$.

3.4 Estimation Techniques

For model 1, we conducted random and fixed-effects panel estimation techniques. The Hausman test statistic comparing random and fixed effects estimation of the model was insignificant. The LaGrange multiplier statistic was significant, requiring the firm-specific error term to be estimated, and suggesting that a pooled OLS estimation would result in biased estimates. Together, the Hausman test and the LaGrange multiplier test indicate that the more efficient random effects estimator is appropriate for estimation of Model 1, although the fixed-effects estimator is consistent.

For model 2 which incorporates SOA, a fixed-effects estimation to account for potential unobserved heterogeneity is not possible because SOA is treated as time-invariant. A technique that allows for the estimation of the effect of SOA and its interaction with joint ventures, while still accounting for potential correlation between unobserved fixed effects and many of the regressors, is the Hausman-Taylor panel instrumental variables estimator (Greene 2003).[7] This estimator incorporates the advantages of the fixed-effects estimator in correcting for unobserved heterogeneity, while also enabling us to allow for the effects of SOA and its interaction with joint ventures.

We next address some ways in which the Hausman-Taylor estimation method may still have the potential for endogeneity. While this estimator corrects for the correlation between potentially endogenous variables and the unobserved fixed effects, it assumes that all regressors

[7] Applied to our model, the Hausman-Taylor estimation technique involves the following steps: 1) Obtain the residuals of a fixed-effects estimation on time-variant regressors only, 2) Explicitly identifying the set of exogenous variables in the system, use the residuals from step 1 as a dependent variable in an instrumental variables regression on SOA and other time-invariant controls that are instrumented upon the exogenous variables, and 3) Use the variance of the residuals from step 2 to calculate the weights, multiplied by the original matrix of regressors, in a Feasible Generalized Least Squares instrumental variables estimation. In the latter step, the original vector of dependent variables is regressed upon the weighted vector of regressors, which is instrumented upon the time-variant variables transformed into their *deviation* from group means, and also upon the group means of variables that are assumed to be exogenous.

are uncorrelated with the varying component of the error term. This assumption would be violated if firms with a high level of intangible value are predisposed to investing in IT or SOA, and to engaging in joint ventures. This concern could be ameliorated with a set of instrumental variables that unambiguously influence IT investment and joint ventures without being correlated with any other unobserved determinants of firm intangible value. Although it is not always possible to identify valid instrumental variables, prior studies have used one year lags of IT capital stock (Bresnahan et al. 2002), sales growth, fixed assets, employees (Anderson, Banker and Ravindran 2006), capital age, or debt to equity ratio (Brynjolfsson and Hitt 2003) as instruments for IT investment. None of these are ideal for this study because they are conceivably related to firm intangible value, and we do not know how effective they can be as instruments for joint venture activity.

Hence, we utilize other techniques to ameliorate potential endogeneity. One way to address potential endogeneity is to observe the impact of joint venture formations, and their interaction with IT, as new information. In order to do this, we modify the model (2) by including a lagged dependent variable (Greene 2003). The Arellano-Bond GMM estimator becomes useful here (Greene 2003). This estimator corrects for potential endogeneity due to simultaneous determination of Tobin's q with the regressors or due to correlations with either the time variant or fixed component of the error term. Further, this estimator allows for consistent estimation when including a lagged dependent variable into the right hand side of the equation even as the panel is relatively short. This estimator instruments regressors upon their lagged values and their prior changes over time. We used the technique as in Beck and Levine (2004) of using one instrument for each lag distance and instrumenting variable, which keeps the number of instruments from proliferating. This prevents the over-fitting of endogeneous regressors and the weakening of the Hansen over-identification test.

3.5 Results

To relate this study to prior studies, we estimate the baseline model with no joint ventures or SOA. Estimation results are in column 1 of Table 2. In accordance with equation (A.3) of Appendix 2 in which we show that the y-intercept has a value of one, estimates of the constant β_o are close to one. The estimate for β_{IT} (1.038) shows that each 10% increase in ratio of IT expenditure to revenue is associated with a 0.1038 increase in Tobin's q.[8] To put this in economic perspective, the average firm in our sample has annual revenues of $10 billion, total replaceable assets worth $10.9 billion, and a Tobin's q of 1.46. For such a firm, a one standard-deviation increase (=0.04) of IT-intensity amounts to ($10 billion × 0.04=) $400 million of additional annual investment in IT. According to the estimate of β_{IT}, this is associated with an increase of 0.0415 in Tobin's q, or a market-value increase of about 0.0415×$10.9 billion, or $453 million. Considering that many of the beneficial impacts of IT may be unobserved externally and hence, undervalued, a 13% (= 453/400 – 1) market value premium on IT investment is substantial. Across all non-dynamic specifications (Tables 2-5), our coefficient estimates for IT range from 0.173 to 2.014; well within the range of -1.72 to 9.24 in Chari et al. (2008), and reasonably close to the range of 0.15 to 0.70 in Bharadwaj et al. (1999).[9]

Table 2 shows estimation results for Model 1. Column 2 in Table 2 shows the direct effect of joint ventures assuming no interaction with IT, or $\boldsymbol{\beta_1} = 0$. Assuming joint ventures have no interaction with IT, the estimate β_{J0} suggests that each joint venture has an impact of 0.104 on Tobin's q. For a firm with $10.9 billion in tangible assets, a joint venture contributes an

[8] Note that units of IT-intensity (as in advertising and R&D), are in straight proportions. Each 1-unit increase (or 100% increase) in IT intensity is associated with an increase in Tobin's q of 1.038. Hence a 10% increase in IT-intensity is associated with a 0.1038 increase in Tobin's q, and a one-standard deviation increase in IT-intensity (4%) is associated with a 0.04152 increase in Tobin's q.

9 Due to the difference in sample years (by a decade), different sample of firms, and our panel estimation techniques on pooled data rather than the separate annual OLS regression estimates in Bharadwaj et al. (1999), results are as expected slightly different from Bharadwaj et al. (1999). Nevertheless, some similarities are seen across the studies. Of the coefficients in Bharadwaj et al. (1999) that are the same in direction (not necessarily statistical significance) across years, our results show the same direction of impact across model specifications in IT, industry concentration, industry Tobin's q, capital intensity, and market share as in the previous study. Other than employees and advertising, none of the other coefficients estimates in Bharadwaj et al (1999) have the same directional effect in all years.

additional \$1.13 billion to firm market value. In the next two columns, we further relax the constraint on β_1. In column 3, we also control for additional characteristics of alliance partners, including R&D, advertising, cash flow, profitability, and number of employees of joint venture partners. Since these figures are not available for all joint venture partners, sample size becomes substantially reduced. However, the coefficients of interaction terms are positive, significant, and slightly larger than in the case where these controls are not included (column 4, Table 2). We also conducted estimates with these partner controls in subsequent models and find that omitting these controls has no significant impact on the results, although it significantly reduced sample size due to availability of partner data. We used White robust standard errors in the Generalized Least Squares estimation to correct for possible non-spherical errors.[10]

Hypothesis 1, which states that IT positively influences the value contribution of joint ventures, is tested in the estimates of the coefficient $\boldsymbol{\beta_1}$ shown in columns 3 and 4. In support of Hypothesis 1, the estimate of $\boldsymbol{\beta_1}$ is positive and significant. Based on column (4) estimates, an increase in one-standard deviation of IT-intensity (4%) increases the impact of each joint venture on Tobin's q by 4×0.0284, or 0.11.[11] For a firm with the mean value of tangible assets, this amounts to an increase in the contribution of each joint venture from \$1.13 billion to \$2.37 billion, or an additional contribution of \$1.24 billion. Once again, fixed effects estimation yield approximately the same coefficient estimates, indicated by the insignificant Hausman statistic, suggesting that unobserved firm fixed-effects are not seriously biasing the results.[12] Estimation results show strong support for H1.

Hypothesis 2 predicts that SOA will have a positive influence on the value contribution of each joint venture. In columns 1-2 of Table 3, we first show random effects panel estimation of

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[10] There would be a reason to cluster errors by individual joint venture in order to correct for the sample containing both sides of a joint venture dyad. But this occurs in such small proportion of cases that the net benefit of such a correction is negligible.

[11] Since a 1% increase in IT-intensity is associated with an increase of 0.0284 in the impact of each joint venture.

[12] Fixed-effects panel estimation yields a coefficient of 2.73 for β_{1a}, significant at α=0.01.

models incorporating SOA. Next, in columns 3-4 of Table 3, we present the results of Hausman-Taylor estimations. Estimation in column 3 accounts for possible endogeneity of IT, SOA, joint ventures, and interaction terms– by instrumenting them on dummy variables for year, 2-digit NAICS industry code, regulation, capital intensity, market share, diversification, employees, advertising, and R&D. Estimation in column 4 uses only year-dummies and industry-level constructs as instruments, accounting for possible endogeneity of firm-level controls. The results are economically significant. An increase in one-standard deviation in the measure of SOA is associated with an increase in the impact of each joint venture formation event by 0.266, according to β_2 in column (4) of Table 3. Assuming a firm with the mean value in tangible assets of \$10.9 billion, this amounts to an increase of \$2.9 billion in the value associated with each joint venture formation (column 5 estimates are even higher). Estimation results indicate strong support for H2.

Results of the Arellano-Bond estimation are in column 5 of Table 3. The Hansen test statistic does not suggest misspecification of the model. Including the lagged value of Tobin's q enables us to interpret the effects of joint venture formation, SOA, IT, and interactions as the impact of new information in Tobin's q (Greene 2003). Lagged values of Tobin's q also incorporate many of the industry, alliance network, and firm level factors that were used as controls in previous models. Here again, estimation results show strong support for H2.

Hypotheses 3a and 3b predict that the impacts of SOA and IT are greater in the case of joint ventures than in non-equity alliances. We incorporate non-equity alliances into the estimation models as shown in Table 4. Columns 1-3 of Table 4 show the staged model estimates for all strategic alliances, not differentiating joint ventures. Column (1) estimates suggest a statistically significant valuation of each general strategic alliance, in the amount of (0.038×\$10.9 billion=) \$414 million dollars for a firm with the sample average amount of tangible assets; smaller than the valuation of each joint venture. However, estimates in columns (2) and (3) show no statistically significant interaction effect between IT-intensity and general strategic alliance network size, suggesting that this interaction effect may be reduced by the inclusion of non-equity alliances. In estimates shown in columns (4) and (5), we separate joint venture and non-equity alliances. Variance inflation factors (VIF) are below 3.5 for all variables, with a mean VIF of 1.67, suggesting no substantial multi-collinearity in these models. A comparative chi-square test shows that the coefficient estimate β_{3a-1} of the interaction term IT $\times$ JV_f is significantly larger than the coefficient estimate β_{3a-2} of the interaction term IT $\times$ Non-EQ_f, with a chi-sqr of 15.88, at a significance of $\alpha = 0.01$; where Non-EQ_f is the number of non-equity alliances formed in a given year. This shows support for H3a, which states that IT-intensity has a greater influence in the value of joint venture than in non-equity alliances. The differences are also economically significant, as IT investment appears to have more than 10 times the effect on the marginal contribution of each joint venture to firm value than on the marginal contribution of each non-equity alliance to firm value.

Another comparative chi-square test shows that the coefficient estimate β_{3b-1} of the interaction term SOA $\times$ JV_f is significantly larger than the coefficient estimate β_{3b-2} of the interaction term SOA $\times$ Non-EQ_f, with a Chi-sqr of 11.57, significant at $\alpha = 0.01$. This shows support for Hypothesis 3b, which states that SOA has a greater influence in the value of joint venture than in non-equity alliances. The differences are also economically significant, as a one standard-deviation increase in SOA will have more than six times the contribution to the value of each joint venture than to the value of each non-equity alliance.

We conducted four robustness checks. First, in place of our current SOA measure, we conducted the same model estimations using the first principle component of SOA, and found the results to be even stronger with this alternative measure of SOA. Second, we used historical Tobin's q and other performance data to test whether the main independent variables are predetermined. We find no evidence that historical performance and Tobin's q influences current alliance network size, SOA, and IT investment—a robustness strategy also carried out in Black and Lynch (2001) to rule out reverse-causality. Third, 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 2003 and beyond, and found coefficient estimates that are consistent with those presented here, although as expected the statistical precision declines along with sample size. 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 long-term program to create business process infrastructure flexibility; having probably begun with earlier incarnations of SOA technologies.

In the fourth robustness check, we considered how these results may be driven by the types of alliance activities involved. Adopting classification schemes from prior literature (Anand and Khanna 2000; Lavie 2007), we identified alliance activities that are technology and marketing based. As argued in prior literature, technology-based alliances involve products or processes in the early stages of development that may require greater depth in collaboration or process-related integration risks. Examples include the joint development of a new technology or product, R&D joint ventures, joint development of software, the integration of IT capabilities to provide a new service, or the integration of manufacturing capabilities. Marketing-based relationships, on the other hand, involve cooperation in the promotion of selling or goods that have already been developed—which arguably (and not in all) cases, allow firms to make joint investments without recombining resources or reconfiguring processes. When limiting the sample of firms to those above the median in the percentage of alliance activities that are technology-based, we again find support for H1 and H2 (column 1, Table 5). Model estimates are insignificant when limited to firms in the lower median in percentage of technology-based alliances (column 2, Table 5). It appears that IT and SOA become more impactful for firms engaging in technology-based alliances, in line with prior studies that consider these activities more costly in terms of coordination, transaction hazards, and reconfiguration (Lavie and Rosenkopf 2006; Rothaermel and Deeds 2004).

4. Discussion

4.1 Main Findings

This study presents several new findings regarding the quantitative economic impact of IT in the context of strategic alliances. First, we find that IT investment has a positive influence on the contribution of joint ventures to firm value. This is consistent with prior theories on the impact of IT on the costs of transaction and coordination. We argue, in addition, that IT facilitates reconfiguration of processes and detection of opportunities for value-creation. Second, we find that even after controlling for the impacts of IT investment, SOA has a positive and significant influence on the contribution of joint ventures to firm value. This provides further evidence of the role of dynamic capabilities of process reconfiguration and opportunity detection, because SOA is known to enhance the flexibility and transparency of business processes. Third, we show that the value contribution of SOA and IT are greater in the case of joint ventures than in non-equity alliances. In joint ventures, transaction and coordination costs may be offset by the hierarchical controls built into them, setting aside the technological basis of alliances, geographic separation, and the scope of activities involved (Gulati and Singh 1998; Zollo et al. 2002). We argue that the tacitness of knowledge sharing and costs of reconfiguration are significantly higher in the case of joint ventures than in non-equity alliances, which helps explain why IT and SOA have greater impacts on the value contribution of joint ventures as compared to non-equity alliances.

4.2 Implications for Research

We contribute to prior literature on the role of IT in inter-organizational relationships by considering alliance activities that have a broader scope in terms of how firms collaborate—

because alliances not only involve the exchange of goods or services, but also the joint development of goods and services. In collaborative alliances, firms establish new inter-organizational business processes, modify existing business processes, and reconfigure resources. We show that IT investment and SOA deployment have a role in enabling firms to leverage value from such partnerships.

While enhanced coordination is one way that IT can contribute to alliance success, the enhancement of flexibility in business processes appears to be another impact of IT. Alliances provide a suitable context for empirical verification of these concepts because they encompass a large variety of organizational forms and governance structures—from those that resemble arms-length transactions to those that involve more deeply intertwined collaborations. This variation is useful in studying the role of IT infrastructure capabilities in leveraging value from frequent collaborative partnerships.

We add to the prior understanding of how enhanced alliance capabilities can have firm-level impacts. Alliance capabilities have a direct bearing upon innovation outcomes such as new products and services, which generate value at the firm level. There can potentially be many firm resources that are being reconfigured around a firm's alliances, in some cases more effectively than others, and which may not be observed as transaction or process-level outcomes. Hence, market-value based firm performance measures are useful in assessing the value that firms derive from alliances.

4.3 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 the IT function with care in the decisions, planning, and oversight of corporate alliances, particularly in the case of joint ventures involving the recombination of resources and reconfiguration of processes. In considering the potential impacts of IT, firms need to consider the importance of flexibility in IT infrastructure and in business processes. 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. In addition, they should consider how the potential synergies with business partners will help leverage other firm capabilities.

4.4 Suggestions for Future Research

Future studies can probe more into the set of practices which distinguish SOA deployment efforts that are successful from those that have been unsuccessful, as SOA has its own set of risks that requires further understanding (Malinverno 2006). Researchers can also consider how IT interacts with other factors in strategic alliances— for example, how firm culture and IT governance might affect alliance success. Second, whereas the unit of analysis of our study is the focal firm, future studies may also consider the role of alliance partners in the joint integration of IT initiatives.

Finally, researchers might explore the role of IT in other strategic contexts and organizational forms in which firms create value—such as internal ventures, mergers and acquisitions, and diversification. In doing so, researchers might use different constructs of IT flexibility. Exploring new contexts is critical, as the role of IT in corporations is evolving towards being more than just a means for improving efficiency, and other mechanisms in the co-creation of value in multi-firm contexts deserve more attention.

To conclude, we found a positive influence of IT investment and SOA on the firm-value contributions of joint ventures. This study synthesizes and builds upon insights from the information systems literature and the corporate strategy literature on alliances; and shows the relevance of research on IS flexibility, strategic agility, and digital options in the context of alliances. Alliances are a means of recombining resources to innovate and to quickly enter new product or market spaces. To do this effectively, firms must also have the capability to reconfigure internal firm resources and detect new opportunities for value-creation.

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Appendix 1: More Variable Definitions

Alliance Network Controls:

Alliance Activity Scope (Scope): The number of cooperative activities per alliance.

International (Foreign): Percentage of alliance partners whose corporate headquarters are located in a different nation from that of the focal firm.

Percentage of Technology-Based Alliances (Tech): Percentage of alliance activities involving the joint development of new technology or technological processes: Manufacturing, Software Development, Research & Development, Internet, Computer Integrated Systems, Telecommunications, Communications, and Exploration.

IT Intensity of Partners (IT Prtnr): 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 Prtrnr): Average free cash flow of alliance partners.

Profitability of Partners (ROA Prtnr): Average return on assets (ROA) of alliance partners. ROA is measured as operating income (Compustat #13) divided by total book value of assets (Compustat #6).

Employees of Partners (HR Prtnr): Average number of employees of alliance partners.

R&D of Partners (R&D Partnr): Average R&D expenditure ratios of alliance partners.

Advertising of Partners (Adv Prtnr)*:* Average advertising expenditure ratios of alliance partners.

Industry controls:

Industry concentration (HERFINDAHL): $\sum_i s_{ij}^2$, where s_{ij} is the market share of firm i in industry j, as in Hou et al. (2006)

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

Weighted Industry Capital Intensity (CAPINTENS): Market-share weighted average capital intensity, defined in Waring (Waring 1996) as Physical Capital/Net Income. Physical capital is book value of physical capital (Compustat #8).

Regulation: Binary variable for regulated industry—these include airlines, banking, pharmaceuticals, and utilities.

Firm controls:

Employees (EMPLOYEES): Number of employees in the firm, which is a measure of firm size.

Firm Advertising Intensity (ADV): The portion of sales spent on advertising. If this value was missing in Compustat, we used the 3-digit NAICS industry average, weighted by the firm's industry segments.

R&D Intensity (RD): The portion of sales spent on research and development. If this value was missing in Compustat, we used the 3-digit NAICS industry average, weighted by the firm's industry segments.

Weighted Market Share (MARKETSHARE): $\sum_j MS_{ij} P_{ij}$ 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. P_{ij} is calculated using the Compustat Industrial Segments database.

Related Diversification (DIVERSE): $\sum P_t \log(1/P_t) - \sum P_u \log(1/P_u)$, as described in Robins et al. (1995), where Pt = Percentage of sales in each 4-digit NAICS industry, and Pu = Percentage of sales in each 2-digit NAICS category.

Appendix 2: Derivation of Baseline Tobin's Q Model

We begin with the assumption that firm valuation (V) equals sum of tangible assets (T) and intangible assets (I):

$$V = I + T \tag{A.1}$$

Intangible value (I) comprises all of a firm's assets that is not captured in its accounting books, including intellectual capital, reputation, or advantages in technology or business processes. Although intangible resources are hard to quantify, prior literature has established that such resources are generated through investment in research and development (R&D) and advertising (Bharadwaj et al. 1999; Villalonga 2004). There has also been an increasing awareness of the contribution of IT towards intangible assets (Bharadwaj et al. 1999; Brynjolfsson et al. 2002):

$$I = \alpha_{it}IT + \alpha_{rd}RD + \alpha_{adv}ADV + Y \quad (A.2)$$

Y represents all additional contributions to firm-intangible value. Combining equations (A.1) and (A.2), and dividing both sides by T, we have:

$$Q = V/T = 1 + (1/T)\ (\alpha_{it}\,IT + \alpha_{rd}\,RD + \alpha_{adv}\,ADV) + y \quad (A.3)$$

Ideally, IT (IT), R&D (RD), and advertising (ADV) would be measured by their capital stocks; but this would require uninterrupted panel data for IT, which we lack. As Wernerfelt and Montgomery (Wernerfelt and Montgomery 1988) point out, since the actual value of intangible capital is difficult to estimate, annual investment figures are used as approximations for their contributions to intangible capital. Bharadwaj et al. (Bharadwaj et al. 1999) present IT-intensity as a ratio of annual IT expenditures to annual revenues; in accordance, we set $\alpha_{IT} = \beta_{IT}\,(T/Sales)$.

$$y = CI + HI + R + MS + D + Log(E) + \sum year_t + \sum_i industry_i \quad (A.4)$$

The construct (y) in equation (4) includes all control variables used in (Bharadwaj et al. 1999): CI is capital intensity, HI is herfindahl index (a measure of industry concentration), R is regulation, MS is market share, D is related diversification, E is the number of employees. In addition, we account for industry-wide effects using two-digit NAICS codes, and for year effects which would correct for annual fluctuations in market-values.

Transforming this into a baseline estimation model, we obtain:

$$Q = \beta_o + \beta_{IT}\,IT + \beta_{ADV}\,ADV + \beta_{RD}\,RD + \beta_{CI}\,CI + \beta_{HI}\,HI + \beta_R\,R + \beta_{MS}\,MS + \beta_D\,D + \beta_E\,Log(Employees) + \sum\beta_{yt}\,year_t + \sum\beta_{Ii}industry_i + u_i + \varepsilon_{i,\,t} \quad (A.5)$$

Table 1: Correlations and Summary Statistics

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	Q	1.00																		
2	Joint Vent. (JV_s)	0.13*	1.00																	
3	IT	0.12*	0.02	1.00																
4	SOA	0.17*	0.09*	0.06	1.00															
5	Ind. Cap. Intens.	-0.22*	-0.05*	-0.16*	-0.03	1.00														
6	Herf. Index	-0.03	-0.05*	-0.02	-0.07*	0.09*	1.00													
7	Regulation	0.00	-0.07*	0.14*	0.07*	0.13*	-0.14*	1.00												
8	Marketshare	0.00	0.08*	-0.08*	0.00	0.11*	0.65*	-0.09*	1.00											
9	Diversificat.	-0.10*	0.10*	-0.02	-0.09*	-0.05*	-0.07*	-0.05*	-0.06*	1.00										
10	Employees	-0.02	0.2*	-0.04	-0.01	0.04*	0.15*	-0.09*	0.35*	0.04*	1.00									
11	Advertising	0.04	0.07*	0.09*	0.01	-0.16*	-0.04	-0.07*	-0.03	0.16*	-0.06*	1.00								
12	R&D	0.14*	0.00	0.03	0.03	-0.15*	-0.03	0.14*	-0.03	0.04	-0.04	0.12*	1.00							
13	Ind. Tobins Q	0.31*	0.11*	0.15*	0.04	-0.41*	-0.1*	-0.01	-0.09*	0.05*	0.01	0.18*	0.14*	1.00						
14	R&D Partnr	0.16*	-0.03	0.08	0.05	-0.18*	-0.11*	0.04	-0.09*	-0.07*	-0.03	-0.03	0.00	0.15*	1.00					
15	Adv. Partnr	0.18*	0.11*	-0.04	0.04	-0.02	-0.07*	-0.04	0.01	0.02	0.02	0.15*	0.03	0.1*	0.14*	1.00				
16	HR Prtnr	0.02	0.08*	0.01	0.08	-0.02	-0.01	-0.09*	0.03	-0.02	0.08*	-0.02	0.00	0.02	-0.1*	0.05	1.00			
17	Cash Prtnr	0.09*	0.07*	0.02	0.06	-0.03	-0.02	0.00	0.00	0.00	0.07*	0.00	0.04	0.05	-0.07*	0.07*	0.64*	1.00		
18	ROA Prtnr	0.00	0.07*	0.03	0.11*	0.06	0.00	-0.05	0.03	0.01	0.06*	0.00	0.00	-0.04	-0.4*	0.03	0.12*	0.16*	1.00	
19	IT Partners	0.06	-0.01	0.09	0.02	-0.14*	-0.01	-0.07*	-0.01	-0.09*	0.00	-0.01	0.01	0.06	0.12*	-0.04	0.04	0.12*	-0.01	1.00
	Observations	1157	1157	1157	666	1157	1157	1157	1157	1157	1157	1157	1157	1157	435	435	435	435	435	434
	Mean	1.46	0.92	0.03	0.00	0.29	0.07	0.17	0.04	0.21	37.76	0.05	0.07	1.96	0.08	0.03	41.71	1430.28	0.07	0.23
	Std Dev	1.32	2.50	0.04	1.00	0.19	0.08	0.37	0.07	0.43	53.94	0.06	0.13	1.16	0.09	0.04	61.63	2660.13	0.18	0.11

Note: * indicates significance at α=0.01.

Table 2 Basic Specifications: Tobin's Q Random Effects Panel Regressions

Model	(1)	(2)	(3)	(4)
β_1: IT $\times$ JV_s			3.986***	2.840***
			(1.539)	(0.752)
JV_s		0.104***	0.105**	0.107***
		(0.044)	(0.048)	(0.015)
IT	1.038*	0.978*	1.17*	0.960
	(0.655)	(0.646)	(0.895)	(0.785)
Cap Intens. Indus.	-0.519**	-0.659***	-1.301***	-0.671**
	(0.269)	(0.266)	(0.468)	(0.4)
Herfindahl	-0.490	-0.114	0.260	-0.150
	(0.549)	(0.444)	(0.599)	(0.738)
Regulation	0.242*	0.302**	0.355*	0.299*
	(0.169)	(0.162)	(0.228)	(0.186)
Market share	1.386**	0.877*	0.728	0.941
	(0.626)	(0.62)	(0.998)	(0.812)
Diversification	-0.368***	-0.387***	-0.539***	-0.38***
	(0.085)	(0.091)	(0.141)	(0.117)
Log (employees).	0.005	-0.023	-0.011	-0.028
	(0.041)	(0.04)	(0.069)	(0.043)
Adv. Ratio	0.813	0.140	-1.472*	0.158
	(0.769)	(0.808)	(1.046)	(0.705)
R&D Ratio	0.149	0.222	-0.098	0.220
	(0.267)	(0.288)	(0.293)	(0.267)
Tobin's q Indus.	0.217***	0.19***	0.298***	0.19***
	(0.076)	(0.065)	(0.11)	(0.033)
Constant	1.154***	1.403***	1.502***	1.420***
	(0.202)	(0.197)	(0.403)	(0.217)
R-sq.	0.217	0.241	0.341	0.253
Chi-sqr	181.00***	187.14***	154.8***	260.33***
Firms	375	375	202	375
Observations	1156	1156	433	1156

NOTE Significant at *10%, **5%, and ***1% level for 1-tailed t-tests. Standard Errors in parentheses. Random-effects Panel Regressions Results for Years 1999-2006: models also include 2-digit NAICS industry nd year dummy variables, estimates of which are not shown.

(1) No joint venture network size effects.
(2) Direct effects only
(3) Additional controls for partner characteristics: partner averages of IT investment, profitability, free cash flow, number of employees, and R&D.
(4) Controlling for nodal firm alliance profile characteristics including activity scope, technological basis of alliance activities, and scope of alliance activities, as in (3); but not for partner characteristics

Table 3 Firm performance models for joint ventures, IT, and SOA. Control variable estimates not shown.

Model	(1)	(2)	(3)	(4)	(5)
Estimator	Random Effects	Random Effects	Hausman - Taylor	Hausman - Taylor	Arellano-Bond GMM
Q_{t-1}					0.319***
					(0.049)
β_2: SOA × JV_f			0.266***	0.266***	0.375***
			(0.038)	(0.036)	(0.056)
β_1: IT × JV_f			9.508***	9.706***	4.841**
			(1.867)	(1.797)	(2.619)
JV_f			0.474***	0.467***	0.593***
			(0.036)	(0.035)	(0.051)
SOA × JV_s		0.107***			
		(0.038)			
IT × JV_s		-0.077			
		(1.008)			
JV_s		0.17**			
		(0.076)			
SOA	0.100**	0.101**	-0.104	-0.255	0.912***
	(0.043)	(0.045)	(0.234)	(0.461)	(0.34)
IT	0.598	0.145	1.305**	1.378**	4.841**
	(0.52)	(0.45)	(0.645)	(0.621)	(2.619)
Constant	1.423***	1.609***	1.092**	0.747	1.342***
	(0.217)	(0.234)	(0.569)	(0.787)	(0.505)
σ_ε			0.52	0.52	
$\rho = \text{sqrt}(\sigma_u^2/(\sigma_u^2+\sigma_\varepsilon^2))$			0.86	0.95	
Wald Chi-2	111.35***	109.63***	397.11***	410.39***	1322***

NOTE Significant at *10%, **5%, and ***1% level for 1-tailed t-tests. Standard Errors in parentheses.
Models also include the same firm-level, industry characteristics, 2-digit NAICS industry and year dummy variables as in Table 2, estimates of which are not shown. We also controlled for alliance activity scope, technological-basis of alliance activites, and international alliances (estimates not shown); 177 firms; 666 observations.
(1) Joint-venture network size.
(2) Joint-venture network size, with interaction terms.
(3) Current-year joint venture formation events, accounting for possible endogeneity of IT, SOA, Joint ventures, and interaction terms.
(4) Accounting for possible endogeneity of market share, diversification, employees, advertising, and R&D, in addition to endogeneity of IT, SOA, joint ventures, and interaction terms.
(5) Dynamic panel GMM estimator; Hansen test static has an insignificant p-value 0.49, indicating no misspecification of the model. The test of AR(2) errors is also satisfactory, at p=0.99.

Table 4 Firm performance models comparing IT and SOA in Joint Venture vs. Non-equity Strategic Alliances

	Model	(1)	(2)	(3)	(4)	(5)
		Random Effects	Random Effects	Random Effects	Random Effects	Hausman-Taylor
$\beta_{3b\text{-}2}$	SOA × Non-EQ$_f$				0.025**	0.026**
					(0.011)	(0.011)
$\beta_{3a\text{-}2}$	IT × Non-EQ$_f$				0.553	0.806**
					(0.454)	(0.439)
	Non-EQ$_f$				0.054***	0.058***
					(0.011)	(0.011)
$\beta_{3b\text{-}1}$	SOA × JV$_f$				0.189***	0.179***
					(0.042)	(0.041)
$\beta_{3a\text{-}1}$	IT × JV$_f$				8.214***	8.38***
					(1.873)	(1.766)
	JV$_f$				0.313***	0.313***
					(0.045)	(0.043)
	IT × Alliances$_s$		0.345	0.153		
			(0.346)	(0.143)		
	Alliances$_s$	0.038***	0.033***	0.038***		
		(0.01)	(0.009)	(0.003)		
	SOA				0.098*	0.004
					(0.062)	(0.227)
	IT	1.336**	2.014***	1.325**	0.815	0.514
		(0.612)	(0.735)	(0.749)	(0.65)	(0.63)
	Constant	1.591***	1.705***	1.586***	1.583***	1.448***
		(0.195)	(0.492)	(0.203)	(0.266)	(0.367)
	R-sq.	0.323	0.413	0.323		
	Chi-sqr	234.18***	205.8***	423.10***	493.87***	515.24***
	Firms	375	202	375	177	177
	Observations	1156	433	1156	666	666

NOTE Significant at *10%, **5%, and ***1% level for 1-tailed t-tests. Standard Errors in parentheses.
Panel Regressions Results for Years 1999-2006. Models also include the same firm-level, industry characteristics, 2-digit NAICS industry and year dummy variables as in Table 2, estimates of which are not shown. We also controlled for alliance activity scope, technological-basis of alliance activities, and international alliances (estimates not shown); 177 firms; 666 observations. JV$_f$ and Non-EQ$_f$ represent annual counts of joint-venture and non-equity alliance formation announcements, respectively. Alliances$_s$ represents imputed total alliance network size.

(1) Assuming no interaction between alliances and IT.
(2) Additional controls for partner characteristics: partner averages of IT investment, profitability, free cash flow, number of employees, and R&D.
(3) Controlling for nodal firm alliance profile characteristics including activity scope, technological basis of alliance activities, and scope of alliance activities, as in (2); but not for partner characteristics
(4) Full model with joint venture formation events
(5) Hausman -Taylor regression accounting for possible endogeneity of IT, SOA, Alliances, and interaction terms.

Table 5 Comparison between Firms Above and Below Median in Percentage of Technology-Based Activities

	Model	Upper Median in Technology Alliances	Lower Median in Technology Alliances
	β_2: SOA × JV_f	0.390***	-0.013
		(0.052)	(0.11)
	β_1: IT × JV_f	5.480**	-18.546
		(2.374)	(14.513)
	JV_f	0.522***	-0.312
		(0.046)	(0.246)
	SOA	0.390***	-0.385
		(0.052)	(0.309)
	IT	0.693	2.115*
		(0.817)	(1.286)
	Constant	1.615*	0.222
		(1.115)	(0.707)
	σ_ε	0.598	0.364
	$\rho = \mathrm{sqrt}(\sigma_u^2/(\sigma_u^2+\sigma_\varepsilon^2))$	0.869	0.942
	Wald Chi-2	341.03***	42.4
	Firms	120	129
	Observations	336	330

NOTE Significant at *10%, **5%, and ***1% level for 1-tailed t-tests. Standard Errors in parentheses.
Hausman -Taylor Instrumental Variable Panel Regressions Results for Years 1999-2006. Models also include the same firm-level, industry characteristics, 2-digit NAICS industry and year dummy variables as in Table 2, estimates of which are not shown. Models account for possible endogeneity of IT, SOA, Alliances, and interaction terms. JV_f represents annual counts of joint-venture formation announcements.