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THE EFFECTS OF INFORMATION TECHNOLOGY AND SERVICE-ORIENTED ARCHITECTURES ON JOINT VENTURE VALUE

Les effets des technologies de l'information et des architectures orientées services sur la valeur des joint-ventures

Completed Research Paper

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Abstract

Alliances represent a variety of governance contexts, and hence provide a rich empirical setting for studying the value-creation mechanisms of Information Technology (IT). We examine the influence of IT investment and flexible IT infrastructure, through Service Oriented Architecture (SOA), in the effect of alliance activity on firm performance. We find that the marginal contribution of each joint venture to intangible 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. Given that the hierarchical controls built into joint ventures may be offsetting many of the transaction and coordination costs inherent in joint venture activities, our results suggest that IT and SOA, through enhancement of flexibility, are likely to be reducing the costs of reconfiguration of firm resources. We test our hypotheses using 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.

Keywords: Information Technology, Service-oriented Architecture, Alliances, Intangible Value, Business Value of IT, Dynamic Capabilities

Résumé

Nous examinons l'influence des investissements en TIC et des infrastructures flexibles basées sur des Architectures Orientées Services (SOA) sur la relation entre les activités d'alliance et la performance de la firme. Nous trouvons que l'influence des TIC et de la SOA est plus forte sur la performance en cas de joint-ventures qu'en cas d'alliances non égalitaires.

Introduction

As firms find new ways to leverage inter-organizational synergies in the global economy, information technology (IT) has transformed the way that organizations collaborate with one another. To some extent, this has been suggested by studies on the role of IT in firm diversification, vertical integration, and firm size (Brynjolfsson, Malone, Gurbaxani and Kambil 1994; Dewan, Michael and Min 1998; Hitt 1999). However, the quantitative economic impacts of IT have not been examined in the context of strategic alliances. While there has been a wealth of literature on the role of IT in inter-organizational relationships, the emphasis has been on the role of IT in enhancing the efficiency and accuracy of transactions in supply-chain relationships (Barua and Lee 1997; Mukhopadhyay and Kekre 2002; Rai, Patnayakuni and Seth 2006; Whitaker, Mithas and Krishnan 2007). Among the large variety of alliances that exist, many are formed not as supply-chain relationships, but as joint ventures or collaborative partnerships aimed at leveraging synergies for creating new products or services, or to expand into new geographical markets. In such collaborative partnerships, IT capabilities can be valuable in the recombination of resources and reconfiguration of processes. In this paper, we examine the influence of investment in IT and in service-oriented architectures (SOA) on the value that firms derive from joint ventures.

Strategic alliances are defined as “voluntary arrangements between firms involving exchange, sharing, or co-development of products, technologies, or services” (Gulati and Singh 1998 p. 293). A joint venture is a distinct type of strategic alliance that involves the creation of a new and distinct economic entity in which multiple partners have a financial stake. This type of inter-organizational governance structure is favored when the tasks and outcomes of cooperation are non-contractible, particularly in collaboration that involves the sharing of tacit knowledge in the joint creation of new products or services (Oxley 1997; Oxley and Sampson 2004). In contrast to arms-length alliances that take the form of licensing agreements, stipulating the transfer of some product or service for a specified price, bilateral joint ventures involve close collaboration and a greater flow of information and knowledge between firms (Gulati and Singh 1998). For example, Anand and Khanna (2000) find strong learning effects in joint ventures and no such effects in alliances involving licensing contracts. Since the joint venture represents a bilateral sharing of risk and effort, partners collaborate, monitor each other, and share information through informal and formal channels. Such inter-organizational collaborations involve shared resources and integrated business processes that are different from what is required in data-intensive supply chain relationships, or in alliances that resemble arms-length market transactions for the exchange of goods or services.

In this paper, we examine and measure the influence of IT investment on the value that firms derive from joint ventures. Given what prior research has shown about the impact of IT in reducing inter-organizational transaction costs and coordination costs (Brynjolfsson et al. 1994), and about the role of IT in the creation of intangible firm capital (Bharadwaj, Bharadwaj and Konsynski 1999; Brynjolfsson, Hitt and Yang 2002), our results reveal that a portion of the intangible capital valuation of IT is in its enabling of inter-organizational relationships.

Additionally, we examine whether the influence of IT investment is greater in the case of joint ventures than in non-equity alliances. Interpreted on the basis of prior theory on transaction costs and coordination costs, a result in the affirmative may seem counterintuitive. In the continuum of alliance types between those resembling arms-length market transactions and those resembling hierarchies, joint ventures more closely resemble hierarchies (Gulati and Singh 1998). Joint ventures involve a bilateral sharing of equity and hierarchical controls that mitigate many of the transaction and coordination costs in which IT is known to make an impact.

Hence the question, why might IT make a greater impact in the case of joint ventures? We argue that the process of establishing a new and distinct economic entity entails exploring new ways of recombining resources to leverage inter-organizational synergies, and this is where IT can be particularly impactful. We test this idea further by considering a set of specific technology practices that, through their enhancement of flexibility in business

processes, are known to facilitate the reconfiguration of business processes. One such technology framework that has generated much interest of late is referred to as service-oriented architecture (SOA).

We use data from over 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 joint ventures over a period of 10 years from 1996-2006. Drawing on our results, and on related studies that highlight the strategic importance of agility and flexibility (Byrd and Turner 2000; Mithas, Tafti, Ye and Mitchell 2008; Sambamurthy, Bharadwaj and Grover 2003), we argue that IT plays an important role in the success of joint ventures because it enables flexibility to reconfigure internal resources, modify business processes, or establish new inter-organizational business processes.

Background Literature

There has been a vast literature examining why firms enter alliances, how they expect to benefit from them, and what the risks are (Gulati 1998). In the context of classical theories and studies on the efficient boundary of the firm, alliances have drawn special interest because they represent a continuum of hybrid forms between markets and hierarchies (Gibbons 2005). Researchers have examined two broad categories of costs and risks associated with any inter-organization relationship: First, there are transaction costs, which arise because alliances involve self-interested agents acting opportunistically (Oxley 1997). Second, there are coordination costs, stemming from the complexities inherent in coordinating a set of disaggregated processes across firm boundaries (Gurbaxani and Whang 1991). To mitigate transaction costs and coordination costs, partners may decide to include certain hierarchical controls into the alliance. The typology distinguishing between markets and hierarchies has been applied to the variation in the types of alliances that exist—such as the distinction between joint ventures and non-equity alliances (Gulati and Singh 1998; Oxley 1997). From these perspectives, the outcomes of predominant interest in prior research have been decision variables such as whether to engage in the alliance, the scope of collaborative activities, and the types of contracts or incentive arrangements used to govern the alliance (Oxley and Sampson 2004).

However, once a firm has decided to engage in an alliance and has committed to a particular configuration of activities, contracts, or risk-sharing agreements, there remain some unanswered questions regarding why some firms are more successful than others at deriving value from alliances. In particular, researchers have begun to learn more about how internal capabilities of the firm influence the relationship between alliance activity and firm performance (Kale, Dyer and Singh 2002; Lavie 2007). IT encompasses another class of capabilities which may enable firms to derive greater value from alliances. Research on the role of IT in inter-organizational relationships has been extensive; but other than case studies and theoretical studies, there has been no empirical examination of the quantitative economic impacts of IT in the context of strategic alliances.

On the whole, the results of prior empirical studies imply that the impact of IT on external coordination has been greater than its impact on internal coordination; and hence that IT has brought about an inward shift in the efficient boundary of the firm (Brynjolfsson et al. 1994; Dewan et al. 1998; Hitt 1999). Extending these findings, it is tempting to conjecture that in the context of alliances, IT investment will have a smaller impact in those that resemble hierarchies. On this point, we suggest a need for caution. This is because prior theoretical arguments based on transaction and coordination costs cannot be applied to the context of joint ventures in the same way as they have been applied to supply chain relationships in which the role of IT is to facilitate the exchange of structured data. Joint ventures, by contrast, often involve the development of new products and services, the recombination of resources, and the exchange of tacit knowledge processes. The impacts of IT will be different in such contexts, and in particular, call for greater attention on the role of IT in enhancing flexibility and agility for the reconfiguration of processes.

There has been greater recognition of the reality that firms often thrive on advantages in innovation, agility, and flexibility—not necessarily to the advantage of incumbent firms with established market positions. This recognition has taken form in a perspective and stream of literature referred to as Dynamic Capabilities, which has evolved from and is arguably a subset of the Resource-based View (RBV) (Eisenhardt and Martin 2000; Teece, Pisano and Shuen 1997). 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. The role of IT in enhancing dynamic capabilities has been gaining greater attention among researchers (Pavlou and El Sawy 2006; Sambamurthy et al. 2003). We build upon this literature by examining the

role of IT investment, and the development of flexible technology infrastructures through investments in SOA-related practices, as firms derive value from joint ventures.

Theory and Hypotheses

Business Value Impacts of Information Technology in Joint Ventures

The impact of IT capabilities on reduction of external coordination costs, the “costs of managing the dependencies between production tasks,” has been a well-studied subject of research (Brynjolfsson et al. 1994 p.1631). IT can enhance coordination capabilities, resulting in greater efficiency in the supply chain, reduced inventory, and higher productivity (Barua and Lee 1997; Lin and Mithas 2008; Mukhopadhyay and Kekre 2002; Rai et al. 2006). Electronic linkages enhance the quality of information exchange between partners, allowing firms to sense and react to sudden changes in supply or demand. Transaction hazards stem from the possibility of opportunistic behavior by business partners, particularly when incentives are misaligned. Clemons, Reddi, and Row (1993) argue that IT investments can reduce coordination costs without necessarily increasing the risk associated with market transactions. The digitization of products and processes enables firms to reduce the asset-specific aspects of inter-organizational investments, such as co-located facilities (Clemons et al. 1993; Kim and Mahoney 2006). Improved coordination and processes linkages, leading to expanded cooperation, can have a positive effect on the level of trust between firms and can reduce contractual hazards (Bensaou 1997; Bensaou and Venkatraman 1995; Nicolaou and McKnight 2006). Through greater mutual monitoring between business partners, greater information sharing, and closer inter-firm linkages, IT can contribute to a reduction in opportunistic behavior (Kim and Mahoney 2006).

A characteristic of joint ventures is that they involve the recombination of knowledge between firms in the process of innovation, and not just the exchange of structured data. As Galunic and Rodan (1998) argue, knowledge has the property of tacitness. The possibility of novelty in recombination increases with the tacitness of routines or knowledge base (Galunic and Rodan 1998). However, tacitness also reduces the likelihood of detection or discovery of opportunities for innovation, and increases the costs of exchange of knowledge resources (Galunic and Rodan 1998). This suggests that there are tools, methods, and technologies that increase detection probability and reduce the costs of resource recombination.

Besides a reduction in transaction costs, the tools and organizational practices that increase the visibility, transparency, and codifiability of knowledge can also enhance the possibilities for detection and reduction in costs of resource recombination (Pavlou and El Sawy 2006; Sambamurthy et al. 2003; Tafti, Mithas and Krishnan 2007). Investments that enable this include not only systems, software, and hardware, but also trained technical staff with business process competencies (Bresnahan, Brynjolfsson and Hitt 2002; Mithas and Krishnan 2008). Through such competencies, firms can better reconfigure business processes to adjust and capitalize on new market opportunities. When processes are digitized, a firm has greater visibility into its own business processes and is thus better able to identify opportunities for innovation. IT-intensity of business processes has led to greater possibilities for recombination of resources in many categories of products and services.

In prior literature, it has been shown that the impact of IT-intensity on firm-performance may be best captured in terms of value-based measures that are forward looking, rather than accounting-based measures that may be vulnerable to changes or idiosyncrasies of accounting practice (Bharadwaj et al. 1999; Brynjolfsson et al. 2002). In addition to business value of IT studies, market-based measures such as Tobin’s q are also commonly used in studies of alliances or joint ventures (Anand and Khanna 2000; Chan, Kensinger and Keown 1997; Lavie 2007). Value-based measures are appropriate because the value derived from the joint ventures, such as new products or services, access to new geographical markets, or new market positioning may not immediately be reflected in accounting measures such as sales, though they are valued by market investors.

Hypothesis 1: The contribution joint ventures to firm value increases with IT-intensity.

Business Value Impacts of Service-Oriented Architecture in Joint Ventures

An implication of the idea that reconfiguration costs are a factor in joint venture value is that there will be a measurable impact of technology infrastructures that enhance the flexibility of business processes. Hence, we consider that some IT systems provide greater flexibility than others. For example, conventional electronic data

interchange (EDI) standards are relatively rigid in the way that they specify document formats. Setting up an EDI-based connection with a new partner is a costly, tedious, and long process (often on the order of months). For this reason, rigid and tightly-coupled EDI-based process linkages, which may be beneficial in the case of long-term supply chain relationships, can lock firms into sub-optimal relationships when the objective is to explore opportunities for the creation of new products or services (McAfee 2005).

Flexible IS systems bring greater flexibility to inter-organizational business processes, and involve fewer maintenance and integration costs when being adapted for business process changes (Chatterjee, Segars and Watson 2006; McAfee 2005). Gosain et al. (2005) present three principles of IS flexibility design: Modularity of interconnected processes, standardization of interfaces, and structured data connectivity. First, process modularity enables firms to more readily decompose parts of business processes in new arrangements without compromising other parts of business processes. Second, standardized interfaces establish a common grammar in the technical specification of application programmer interfaces (API's), reducing their specificity. Third, structured data enables a common grammar in the labeling of items such as product numbers or inventory process codes. These three principles of design are highly consistent with discussions of IS flexibility in prior research, notably in Byrd and Turner (2000) and Duncan (1995).

Service-oriented architecture (SOA) is widely considered to embody such principles of flexible IS design, featuring a modular design framework and structured data connectivity (Natis and Schulte 2003). SOA utilizes messaging protocols such as XML that are more easily configurable than legacy messaging protocols such as EDI. Applications built on top of SOA can be configured more rapidly than those built on top of legacy infrastructures. Proper deployment of SOA usually occurs in conjunction with the re-design of business processes to make them more integrated, streamlined, and flexible (McAfee 2005). Hence, SOA can facilitate greater agility and flexibility in the establishment of new inter-organizational process linkages without sacrificing the efficiency of these channels. Beyond a base level of IT infrastructure capability, the deployment of SOA can bring additional flexibility in business processes that enables firms to further leverage value from joint ventures.

Hypothesis 2: The contribution of each joint venture to firm value becomes more positive with investment in SOA.

Comparative Impacts of Information Technology in Joint Ventures vs. 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 be particularly impactful in reducing the costs of reconfiguration required in the formation of joint ventures. With greater accessibility of information and visibility into business processes, firms are better able to detect opportunities for innovation and reduce the costs of resource recombination, increasing the value that can be derived from joint ventures. Zollo and Winter (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: Ceteris paribus, the influence of IT-intensity on the marginal contribution of each alliance to firm value will be greater in the case of 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: Ceteris Paribus, the influence of SOA on the marginal contribution of each alliance to firm value is greater in the case of joint ventures than in non-equity alliances.

Research Design and Methodology

Data

The data for this study comes from several sources. First, we obtained the data related to IT spending and SOA-related practices 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. 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, we retrieved 2,005 announcements of joint ventures between 1996 and 2006, as well as an additional 6,673 announcements of other non-equity alliances, from the SDC Platinum Database (a product of The Thomson Corporation). Third, we retrieved performance variables, as well as firm-level and industry-level controls from the Compustat North America database. Table 1 is an abridged table of summary statistics and correlations; the full table of correlations and summary statistics are available from the authors.

The final sample size included 375 firms and 1157 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 in SOA were asked. In this paper, we present estimation results based on the smaller panel dataset (N=666) that includes data on SOA. We use the larger panel dataset (N=1157) for robustness-checking of tests related to aggregate IT-investment.

Table 1: Abridged Table of Correlations and Summary Statistics

* indicates significance at $\alpha=0.10$

		1	2	3	4	5
1	Q	1.00				
2	Joint Vent. (JV _f)	0.12*	1.00			
3	Non Equity. Alliance (Non-EQ _f)	0.27*	0.57*	1.00		
4	IT	0.12*	0.01	0.04	1.00	
5	SOA	0.17*	0.07*	0.14*	0.06	1.00
	Observations	1157	1157	1157	1157	666
	Mean	1.46	0.27	2.11	0.03	0.00
	Std Dev	1.32	1.00	6.80	0.04	1.00

Estimation Model and Results

In this section we develop the estimation model. Each variable mentioned here is defined in greater detail in the Appendix. We begin with the assumption that firm valuation equals sum of tangible assets (T) and intangible assets (I):

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

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):

$$I = \alpha_{it}IT + \alpha_{rd}RD + \alpha_{adv}ADV + Y \tag{2}$$

We utilize data from separate IWeek surveys for each year from 1999 to 2006. In each year, the IWeek survey provides annual IT expenditure as a percentage of sales (IT). It is important that the IT investment figure include not only technology hardware, software, and systems, but also salaries and recruitment of IT professionals, IT-related services and training. Given the comprehensiveness of this measure in capturing all of a firm’s IT-related expenses, this also helps to capture overall information-intensity of a firm’s operations. Y represents all additional contributions to firm-intangible value. Combining equations (1) and (2), and dividing both sides by T, we have:

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

As 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. (1999) present IT-intensity as a ratio of annual IT expenditures to annual revenues; for consistency of interpretation, we set $\alpha_{IT} = \beta_{IT} (T/Sales)$. Tobin’s q, the ratio of market value to book value, is calculated using the method described in Chung and Pruitt (1994); except that we used average market value over twelve months to correct for stock market volatility that would affect the numerator of the Tobin’s q measure. The construct (y) in equation (3) includes all additional determinants of intangible value, including alliances and their interaction with IT and SOA, and all control variables used in Bharadwaj et al. (1999). 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 the estimation model, we obtain:

$$Q = \beta_0 + \beta_{IT} IT + (\beta_{j0} + \beta_1 IT + \beta_2 SOA) \times J_f + \beta_{SOA} SOA + X_C \beta_C + X_{AC} \beta_{AC} + u_i + \varepsilon_{i,t} \tag{4}$$

The matrix X_C represents the following control variables: 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 Bharadwaj et al. (1999). The matrix X_C also includes year and industry dummy variables at the level of two digit NAICS codes. The matrix X_{AC} represents 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. Tobin's q (Q) is the ratio of market value to book value. SOA is a proxy for deployment of flexible IT infrastructures, and is treated as time-invariant due to its having been measured in only one of the years in the panel. 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 (Natis and Schulte 2003). Hence, our panel is short enough that we can reasonably assume that the flexible IT infrastructure practices, for which SOA serves as a proxy, are constant over this period while it is long enough to correct for potential unobserved heterogeneity. This was confirmed by running auxiliary regressions with time windows of various lengths; as the effects of SOA did not change significantly.

Due to the lack of termination dates in the dataset of alliances, some studies have used imputation methods to determine total alliance network size. For example, Lavie (2007) assume an average alliance lifespan of three years due to lack of data on termination dates. For our purposes, such methods of imputation are not ideal because there is the potential for unobserved heterogeneity in joint venture lifetimes among firms, which results in correlations in joint venture network size across years. Instead, there is greater precision in considering the effects of individual joint venture *formation* events within each given year. Not only does the number of new joint venture formation announcements closely track the actual size of a firm's existing joint venture network, but this approach will eliminate the problem of cross-correlations in the measurement of joint venture network size across years. Further, the challenges of resource recombination and process reconfiguration are greatest in the immediate months following a joint venture formation—particularly when we consider that joint ventures that last beyond a decade in age begin to resemble established firms.¹ Therefore, our hypothesis testing utilizes joint venture formation (J_f) rather than joint venture network size.

The estimation model may have a potential endogeneity issue in that we cannot rule out the possibility that firms with a high level of intangible value are predisposed to investing in IT and to engaging in joint ventures. Ideally, this problem could be addressed with a set of instrumental variables that unambiguously influence IT investment and joint ventures without being correlated to any other unobserved determinants of firm intangible value. Although it is not always possible to identify good instrumental variables, prior work has 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 particularly suitable 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 address 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 include a lagged dependent variable (Greene 2003) in the model, and use the Arellano-Bond GMM estimator (Greene 2003). This estimator instruments regressors upon their lagged values and their prior changes over time, and corrects for potential endogeneity due to simultaneous determination of Tobin's q with the regressors or due to correlations of regressors 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. We used the technique as in Beck and Levine (2004) of using one instrument for each lag distance, which keeps the number of instruments from proliferating. This prevents the over-fitting of endogenous regressors and the weakening of the Hansen over-identification test.

Our use of the Hausman-Taylor estimator also accounts for some of the potential endogeneity arising from correlation between unobserved fixed effects and many of the regressors (Greene 2003). This estimator incorporates the advantages of the fixed effects estimator in correcting for unobserved heterogeneity, while also allowing us to estimate for the impact of SOA and its interaction with joint ventures. The advantage of this technique over the fixed effects panel estimator is that it allows estimation of SOA, which is treated as a time-invariant construct.

¹ For example, consider the joint venture between Dow Chemical and Corning Glass Works in 1943 that continues today as Dow Corning.

Estimation results are presented in Table 2. Column (1) shows results of the Arellano-Bond dynamic panel GMM estimator. The 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 $p=0.99$. Columns (2-4) show results of the Hausman-Taylor instrumental variables panel estimator, without and with interaction terms, accounting for endogeneity of IT, SOA, joint ventures, and interaction terms. For instruments, column (2) utilizes year and two-digit industry dummy variables, similar to Brynjolfsson and Hit (2003), as well as industry-level average of physical capital intensity, Herfindahl index, industry regulation indicator, and industry-average Tobin's q . In addition, firm-level constructs of market share, diversification, employees, advertising, and R&D are used as instruments in column (2). Column (3) uses only time and industry-level constructs as instruments. We believe that the limited set of instruments in column (3) is appropriate, because while firm-level constructs are more likely to be endogenous, industry-level factors and annual changes in competitive environment will exogenously influence firms' inclination to engage in joint ventures and also to invest in IT. Nevertheless, coefficient estimates using the different sets of instruments do not appear to affect the results of our hypothesis testing.

Coefficients of interest involve the interaction terms. 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. One source of possible non-spherical errors is the presence in the data sample of both sides of an alliance dyad. These accounted for less than 5% of joint ventures, and hence there we found no net benefit in clustering errors by individual joint venture. We also found that dropping such alliances from the sample would have had a negligible effect on results.

In support of Hypotheses 1 and 2, we observe that IT-intensity and SOA both have a significant positive moderating influence on the value of each joint venture, as seen in the estimates of coefficients for $IT \times JV_f$ and $SOA \times JV_f$. A comparative Chi-square test statistic of 15.88 shows that the coefficient estimate of the interaction term $IT \times JV_f$ is significantly larger than the coefficient estimate of the interaction term $IT \times Non-EQ_f$, at a significance-level of $\alpha = 0.01$. 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 to the contribution of each non-equity alliance. This shows support for Hypothesis 3a. Another comparative chi-square test shows that the coefficient estimate of the interaction term $SOA \times JV_f$ is significantly larger than the coefficient estimate of the interaction term $SOA \times Non-EQ_f$, with a Chi-square of 11.57, significant at $\alpha = 0.01$. Here again, 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. This shows support for Hypothesis 3b, which states that SOA has a greater influence in the value of joint ventures than in non-equity alliances. For the sake of robustness, we conducted tests of Hypotheses 1 and 3a, which do not involve SOA, using the larger panel dataset of 1157 firm-year observations.² We also conducted hypothesis tests using random-effects specifications. Results of the robustness checks were consistent with those presented here.

Discussion

Prior research suggests competing arguments regarding the impact of IT investment on the value of collaborative alliances. On one hand, aggregate investments in IT lead to greater digitization and codification of business processes (Mithas and Whitaker 2007); which then make them more amenable to reconfiguration that is helpful in alliances. However, anecdotal evidence suggests that some firms' IT investments have actually made them more rigid in their business processes in a way that inhibits the speed at which they can adjust to accommodate market changes. For instance, in the 1990's, Allstate invested heavily in a system that streamlined many business processes, but also had the negative effect of making it difficult to alter or modify those business processes (Weier 2007). Applying theories of Transaction Cost Economics, some have argued that relation-specific IT systems, those involving high setup and switching costs, have favorable contractual properties in inter-organizational contexts (Kim and Mahoney 2006). On the other hand, this runs counter to the prevailing trend in practice towards greater use of service-oriented architectures (SOA), which as technology vendors and articles in the business press claim, have enhanced business process flexibility (Cearley, Abrams and Smith 2006).

Against this backdrop of competing arguments and anecdotal evidence, our results suggest that IT investments and investments in flexible IT infrastructure do enable firms to derive greater value from collaborative joint ventures.

² Results of these additional tests are available from the authors.

The Dynamic Capabilities perspective, with its emphasis on resource recombination and process reconfiguration, offers a clarifying theoretical lens to help understand this phenomenon.

We contribute to prior literature 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.

The role of IT in enhancing flexibility and agility helps explain two of our findings. First, it helps explain the substantial impact of SOA in enhancing the value of joint ventures, even controlling for the impacts of aggregate IT investment and the interaction of IT with alliances. Second, it helps explain why both IT and SOA have a greater impact in the case of joint ventures, whose hierarchical controls are designed to reduce the coordination and transaction costs in which IT is known to make an impact. While enhanced coordination or reduced transaction costs are ways that IT can contribute to alliance success, these findings suggest that there is also an important role for IT in the enhancement of flexibility in business processes. 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 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 are deriving from joint ventures.

This study synthesizes and builds upon insights from the information systems literature and the corporate strategy literature on alliances. For example, while researchers in strategy have recognized the role of strategic flexibility in alliances, such flexibility has been considered primarily on the basis of legal, social, and relational factors (Young-Ybarra and Wiersema 1999). Our contribution is to consider the IT infrastructure capabilities that enable firms to leverage value from collaboration depth while also maintaining flexibility. Building upon previous research on IS flexibility, strategic agility, and digital options, our study provides a validation of these frameworks through quantitative firm performance measures. 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.

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. By using IT to integrate business processes, managers can increase the probability of alliance success.

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.

Table 2 Firm performance models comparing IT and SOA in Joint Venture vs. Non-equity Strategic Alliances; Dependent variable is Tobin's Q

Each model includes control variables for the firm-level characteristics of R&D investment ratio, advertising ratio, log of employees, diversification, and market share; as well as industry characteristics of regulation, Herfindahl Index, average intensity of physical capital, and industry average Tobin's q. In addition, we used 2-digit NAICS industry and year dummy variables. We also controlled for alliance activity scope, technological-basis of alliance activities, and international alliances. Estimates for control variables are not shown. Detailed variable definitions are in the appendix. 177 firms; 666 observations. Significant at *10%, **5%, and ***1% level for 1-tailed t-tests. Standard Errors in parentheses

	Model	(1)	(2)	(3)	(4)
		Arellano-Bond GMM	Hausman-Taylor ^a	Hausman-Taylor ^b	Hausman-Taylor ^b
β_{3b-2}	SOA \times Non-EQ _f				0.026**
					(0.011)
β_{3a-2}	IT \times Non-EQ _f				0.806**
					(0.439)
	Non-EQ _f				0.058***
					(0.011)
β_{3b-1}	SOA \times JV _f	0.375***	0.266***	0.266***	0.179***
		(0.056)	(0.038)	(0.036)	(0.041)
β_{3a-1}	IT \times JV _f	4.841**	9.508***	9.706***	8.38***
		(2.619)	(1.867)	(1.797)	(1.766)
	JV _f	0.593***	0.474***	0.467***	0.313***
		(0.051)	(0.036)	(0.035)	(0.043)
	SOA	0.912***	-0.104	-0.255	0.004
		(0.34)	(0.234)	(0.461)	(0.227)
	IT	4.841**	1.305**	1.378**	0.514
		(2.619)	(0.645)	(0.621)	(0.63)
	Q _{t-1}	0.319***			
		(0.049)			
	Constant	1.342***	1.092**	0.747	1.448***
		(0.505)	(0.569)	(0.787)	(0.367)
	σ_{ε}		0.52	0.52	0.49
	$\rho = \text{sqrt}(\sigma_u^2 / (\sigma_u^2 + \sigma_{\varepsilon}^2))$		0.86	0.95	0.85
	Chi-sqr	1322***	397.11***	410.39***	515.24***

a: HT estimator uses additional firm-level constructs as instruments: market share, diversification, employees, advertising, and R&D. b: Uses only year and industry-level constructs as instruments.

Appendix: More Details on Variable Definitions

Dependent Variables

Tobin's q (TOBINSQ): The monthly average ratio of market value over book value. Chung et al. (1994) show that the following method of calculating Tobin's q provides a close approximation to other more theoretically correct models, and this method is also used in Brynjolfsson et al. (2002) and Bharadwaj et al. (1999):

$$\text{Tobin's } q = (\text{MVE} + \text{PS} + \text{DEBT})/\text{TA}$$

PS = Liquidating value of the firm's outstanding preferred stock

TA = Book value of total assets

DEBT = (Current liabilities – Current assets) + Long term Debt + Book value of inventories

Due to the volatility of stock market prices, we used the average of the 12 end of month market prices.

$$\text{MVE} = \sum_{m=1}^{12} \text{Stock Price}_{i,t,m} \times \text{Outstanding Shares}_{i,t,m}$$

Independent Variables

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.

SOA deployment (SOA): This is a proxy for deployment of flexible IT infrastructures. This measure incorporates survey questions regarding: 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*).

We utilized unrotated principle components analysis (PCA) to validate this measure, and found that all items comprising the measure of SOA load positively onto the first principle component with a weighting of 0.4 or greater. 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. The Kaiser- Meyer-Olkin measure of sample adequacy, at 0.7, suggests that the indicator variables are internally consistent.¹ Correlations and factor loadings of the SOA measures are listed in Table 6. 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.¹ For the sake of parsimony and consistency with prior studies using linear regression models, we present estimations using the standardized summative measure of standardized items—also done in Bresnahan, Brynjolfsson and Hitt (2002).

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:

$$\text{SOA} = \text{STD}(\text{STD}(\text{SBA}) + \text{STD}(\text{XML}) + \text{STD}(\text{WebServ}) + \text{STD}(\text{SOA_BREADTH}))$$

Table 3. Principle Component Analysis results for SOA. Loadings of the first unrotated principle component Item	
Services-based architecture (SBA)	0.41
Use of eXtensible Markup Language (XML)	0.53
Use of Web Services layer of architecture (WebServ)	0.49
Breadth of SOA use (SOA_BREADTH)	0.56

Alliance Network Size (Alliance_s); Joint Venture Network Size (JV_s): Following Lavie (2007), we imputed the firm's alliance network size as number of new alliance partners announced from year *t*-2 through year *t*.

Joint Venture Network Formations (JV_f): The number of newly formed joint ventures in a given year *t*.

Industry controls:

Industry concentration: Measure of industry concentration, following the procedure described in Hou et al. (2006). The Herfindahl index for some industry *j* is measured as follows:

$$\text{Herfindahl}_j = \sum_i s_{ij}^2, \text{ where } s_{ij} \text{ is the market share of firm } i \text{ in industry } j.$$

Weighted Industry Average Tobin's q: Market-share weighted average Tobin's *q* for all firms listed under the same three-digit NAICS code.

Weighted Industry Capital Intensity: Market-share weighted average capital intensity, defined in 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: Number of employees in the firm, which is a measure of firm size. We used the log of this figure in our models.

Firm Advertising Intensity: A measure of marketing capability, measured as 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: A measure of R&D capability, measured as 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: A measure of market share, as listed in Bharadwaj et al. (1999). For firm *i*, market share is calculated as follows:

$$\text{MARKETSHARE}_i = \sum_j MS_{ij} P_{ij}$$

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: We used the entropy measure as listed in Bharadwaj et al. (1999), also described in Robins et al. (1995):

$$E_r = E_t - E_u = \sum P_t \log\left(\frac{1}{P_t}\right) - \sum P_u \log\left(\frac{1}{P_u}\right)$$

E_r = related component of entropy

E_t = entropy as defined at the 4-digit NAICS level

Eu = entropy as defined at the 2-digit NAICS level

Pt = Percentage of sales in each 4-digit NAICS industry

Pu = Percentage of sales in each 2-digit NAICS category

Alliance Network controls

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

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

Percentage of Technology-Based Alliances: 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.

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