Organization Science
Vol. 18, No. 5, September–October 2007, pp. 865–880
ISSN 1047-7039 | EISSN 1526-5455 | 07 | 1805 | 0865
DOI 10.1287/orsc.1070.0285

The Influence of Information Technology on the Use of Loosely Coupled Organizational Forms: An Industry-Level Analysis

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Information technology (IT) enhances coordination both within the firm and between the firm and its external partners. Consequently, IT investment can promote both loosely and tightly coupled organizational forms. Indeed, in some industries, widespread investment in IT is associated with high levels of disaggregation. In other industries, this is not the case. We argue that the specific influence of IT on firm boundaries depends on the broader industrial context. We investigate conditions whereby IT investments enable industries to be more loosely coupled through alliance formation and the use of contingent workers. We use transaction cost and modular systems theory to ground our theoretical development. The extent to which industrywide IT investment is associated with loosely coupled organizational forms depends on (1) limited asset specificity because of industry standards, (2) the level of industry uncertainty resulting from technological change, and (3) the overall complexity of the industry in terms of diverse inputs. Specifically, when industry standards exist, IT investment leads to greater use of both alliances and contingent workers. IT investment has a stronger positive relationship with the use of contingent workers when levels of technological change are low as compared to when levels of technological change are high. When there are high levels of input diversity *and* industry standards exist, IT investment led to an increased use of contingent workers. Our analyses provides a more refined view of IT influence on firm boundaries.

Key words: information technology; organizational form; interorganizational relationships

In many industries, traditional hierarchical structures have given way to loosely coupled organizational components with semipermeable boundaries (Zenger and Hesterly 1997). Hierarchies have been transformed into networks of strategic partnerships with suppliers, distributors, and competitors (Achrol 1997, Hitt 1999). Similarly, in some industries, firms have come to rely more heavily on contingent workers that they do not directly employ (Estevao et al. 1999). In such industries, these loosely coupled organizational forms provide greater flexibility for recombining resources to meet market demands than vertical integration (Schilling and Steensma 2001). Yet, in other industries, hierarchy remains entrenched. Indeed, some firms have significantly expanded their boundaries in pursuit of greater economies of scale or scope (Jacobides 2005).

The development and adoption of information technologies (ITs) over the last few decades is arguably a primary driver in shaping the modern industrial organization, including firm scale and scope (Afuah 2003, Stiroh 2002). Although there is some evidence that IT investment[1] has influenced firm boundaries, debate remains over the nature of its influence (Brews and Tucci 2004). IT enhances communication and coordination both *between* the firm and its partners, and *within* the firm itself (Afuah 2003, Hitt 1999, Malone et al. 1988). On the one hand, IT investment decreases the need for hierarchy by reducing the costs of coordinating with external partners and enabling more activities to be moved outside of the firm boundaries (Brews and Tucci 2004, Brynjolfsson et al. 1994, Hitt and Brynjolfsson 1997). On the other hand, lower communication costs resulting from various IT tools also enable greater centralized decision making and more highly integrated firms (Afuah 2003, Bolton and Dewatripont 1994).

Thus it is not immediately clear whether IT investment promotes the integration of more activities within the firm (tight coupling) or a greater reliance on external partners (loose coupling) (Afuah 2003, Brews and Tucci 2004). Such indeterminacy indicates a need to delve more deeply and examine the contingencies influencing the relationship between IT investment and organizational forms (Baron and Kenny 1986). Here we explore the conditions under which IT investment leads to the use of loosely coupled organizational forms, including alliances and the use of contingent workers (Afuah 2003).

We argue that IT investment can promote both loosely and tightly coupled organizational forms. The specific nature of IT's effect on firm boundaries, however, depends on the broader industrial context. Transaction cost economics (Williamson 1985) and modular systems theory (Schilling 2000) highlight fundamental pressures and opportunities in the industrial context that influence the relationship between IT and firm boundaries. Transaction cost economics suggests that arms-length market contracts are the default governance mechanisms because of the efficiencies of market competition. However, high transaction costs (e.g., search, monitoring, enforcement) bring pressure on the firm to control exchanges through hierarchy (i.e., tight coupling), and avoid transaction costs associated with loose coupling (Williamson 1985). Transaction costs are particularly prevalent during times of uncertainty and when asset specificity is high.

Modular systems theory is highly complementary with transaction cost economics, but highlights conditions where a system benefits from loose coupling. According to the theory, when a system is composed of diverse inputs, loose coupling will provide the necessary flexibility to more easily create new and potentially valuable configurations that are inherent in a broader array of inputs (Schilling 2000). In general, both a modular systems perspective and a transaction cost perspective yield many of the same predictions. However, the modular systems perspective extends the transaction cost perspective by providing insight on factors that increase the value of loose coupling (i.e., diverse inputs) rather than simply treating loose coupling as the default from which firms deviate from to avoid transaction costs.

Our premise is that firms balance their desire for the flexibility derived from loose coupling and their need for the hierarchical control derived from tight coupling. The uncertainty resulting from technological change, the reduction in asset specificity because of industry standards, and the diversity of inputs in the production process influence the relative value of flexibility and control. We examine the interaction between these industry characteristics and IT investment to explain why industries vary in their reliance on loosely coupled organizational forms. We contend that in certain industrial contexts, the external coordination capabilities derived from IT investment promotes greater use of loosely coupled organizational forms, whereas in other industry contexts, IT investment plays less of a role.

We begin by describing how firms gain flexibility by using alliances and contingent workers, albeit at the expense of control. We then discuss how various IT tools such as decision support and supply chain management systems facilitate coordination both between and within firms. We develop a contingency model suggesting when IT investments will be more strongly linked to the use of loosely coupled organizational forms such as alliances and contingent workers. Our analysis provides a more refined view of IT influence on firm boundaries.

Background

Organizational Flexibility

The boundaries of firms are determined, in part, by their need to be flexible. Organizational flexibility is a firm's ability to do new things quickly by recombining resources (Schilling and Steensma 2001). Such flexibility enables firms to easily adapt when there is a need to change volume output, product configurations, and strategy (Hitt et al. 1998). At an operational level, flexibility is vital to several manufacturing strategies such as shortening time-to-market, lean manufacturing, and stockless inventory (Zammuto and O'Connor 1992). At strategic levels, flexibility enables firms to more easily change their competitive focus regarding service, quality, or low cost (Hayes and Pisano 1994). Organizational flexibility can be attained, in part, through loosely coupled organizational forms. Firms can specialize in a few key activities while accessing other activities through relationships with outside parties (Afuah 2003, Brews and Tucci 2004). The firm can readily change its mix of activities by changing partners or the terms of an existing partnership.

Many firms achieve flexibility through the use of strategic alliances, including R&D collaboration, shared manufacturing arrangements, and common distribution agreements. Alliances are particularly flexible because of the focal firm's relatively limited commitment with its partners as compared to hierarchical control found in more highly integrated firms (Folta and Miller 2002, Kogut 1991). For example, to reduce volume output, an organization can remove itself from an alliance. The organization does not need to contend with internal employee contracts that can be costly to retract or difficult to sell to another firm (Duhaime and Schwenk 1985). Likewise, to change a product configuration, an organization can form an alliance with a partner that provides the necessary complementary assets. To alter strategy, an organization can adjust its alliance portfolio by ending old alliances and forming new ones. Organizational flexibility via alliances is a function of the partner's limited commitment and the relative ease in terminating or engaging in new alliances as compared to hierarchy.

A second means of gaining flexibility via loosely coupled relationships is through the use of a contingent work force. Using such labor is a quick and effective way to bring new knowledge into a firm without incurring all the costs associated with direct employment (Lepak and Snell 1999, Mayer and Nickerson 2005). Contingent workers often receive fewer benefits, and their numbers can be easily increased or decreased to match peaks and valleys in demand, avoiding both overtime pay and idle capacity. The reduced labor costs enable firms to hire additional professionals within the firm's increasingly narrow realm of specialization (Shimizu and Hitt 2004). Contingent workers offer organizations flexibility similar to alliances. Firms can implement major changes rapidly because they can hire in new capabilities quickly and can shed activities with fewer encumbrances.

However, flexibility through loosely coupled organizational forms comes at the expense of control. Loosely coupled relationships entail sharing control with one's partners and can create managerial challenges. Alliance partners may have objectives that run contrary to those of the firm (Reuer and Leiblein 2000). Contingent workers may be difficult to manage because they lack a direct tie to the firm (Davis-Blake et al. 2003). A highly integrated organization that contains a wide array of functions within its boundaries provides a level of control that loose coupling does not provide. Managers can readily exert control via fiat over those resources that reside within their firm (Williamson 1985). Costly negotiations with partner firms and suppliers are unnecessary because the key relationships are within the organization. Pending available resources, changing volume output, strategy, and product configurations are merely a matter of issuing internal directives. Although flexibility is generally desirable, the resulting loss in control can negate the benefits of flexibility.

The Role of IT in Enhancing Coordination Across and Within Firms

Regardless of whether firms pursue the flexibility of loose coupling or the control of tight coupling, coordination capabilities are essential. For loosely coupled organizational forms such as alliances and contingent workers to be effective, firms need to efficiently coordinate and monitor these outside agents. For a hierarchy to be effective, the firm needs to efficiently coordinate and integrate the various functions and divisions within its boundaries (Hennart 1993, Williamson 1985). IT plays a vital role in providing the needed coordination. Aside from electricity, IT is considered to be one of the two most important general-purpose technologies to date in terms of economic impact (Jovanovic and Rousseau 2005). Organizations in every industry have invested, to varying degrees, in a variety of IT tools that can facilitate coordination both within and across firm boundaries.

For example, Group Decision Support Systems (GDSS) combine communication, computing, and decision support technologies to facilitate unstructured team problem solving (DeSanctis and Gallupe 1987). Such systems provide a shared work space and encourage idea generation, synthesis, and exploration of important issues to support team problem solving (Nunamaker et al. 1991). Web-enabled GDSS tools facilitate virtual teams composed of geographically dispersed members. Media technologies commonly used for virtual work spaces include electronic whiteboards that enable members to see where others are pointing and gesturing, instant poll capabilities to gauge member opinions on issues under discussion, instant messaging for back-channel communication, and discussion threads for conflict identification and resolution (Bordetsky and Mark 2000, Majchrzak and Malhotra 2003). Such tools break the boundaries of time and space by enabling any-place, any-time, and any-platform interaction. GDSS tools and associated media technologies played an integral role in the success or failure of virtual teams (Majchrzak and Malhotra 2003). With the appropriate tools, virtual teams develop and implement policies worldwide, often with fewer problems than conventional teams that meet face to face on a regular basis (Schmidt et al. 2001). A number of firms, including Boeing, Dell, GE, HP, IBM, and Infosys use such technologies for coordinating expertise that span the continents (Friedman 2005).

By using the tools described, companies can leverage their expertise on a global scale and efficiently coordinate a broader array of diverse markets (Jarvenpaa and Leidner 1999, Majchrzak et al. 2004). Minimal face-to-face interactions are required because internal projects are conducted through electronic media (Majchrzak et al. 2004). Bureaucratic costs of coordination across functions, divisions, and geography are reduced, thereby increasing minimum efficient scale (Afuah 2003). GDSS and media technologies enable the firm to expand its scale and scope and still maintain the feel and control consistent with a smaller firm (Montoya-Weiss et al. 2001). In effect, larger hierarchies can be managed at lower costs than otherwise possible.

However, virtual team members do not necessarily have to come from within the firm. GDSS and media technologies also facilitate accessing talent and expertise that is outside of the firm. External partners can more easily plug into a virtual team when GDSS and media technologies are employed. Because distance is no longer a significant constraint, these IT tools have created a more transparent and robust global market for talent outside of the firm boundaries. A firm can just as easily collaborate with partners or contract with contingent workers that are 8,000 miles away as those that are 8 miles away.

One example of GDSS and media technologies facilitating coordination both within and across firms is Boeing's Rocketdyne virtual team, which designed a thrust chamber for a new rocket engine (Malhotra et al. 2001). The virtual team was composed of Boeing employees from different divisions as well as individuals from Raytheon and MacNeal-Schwendler. The team members had no experience working together and lacked a common set of norms for coordination. The only time that all members of the team were colocated was on the last day of the project for a celebratory function. In the end, development costs were significantly lower than expected and the full design effort took ten months as compared to the six years to do a comparable design-manufacture effort in the past. The success of the team is largely attributed to the ability of GDSS to coordinate such a diverse set of individuals coming from various functions within Boeing as well as from partner firms.

Enterprise Resource Planning (ERP) Systems. ERP[2] systems have been traditionally used for coordinating key business and management processes within a firm. ERP systems enhance internal coordination by standardizing various functions based on best practices. ERP modules automate data-oriented management operations and processes such as inventory control, production, sales support, accounting, and human resources management (Hitt et al. 2002). Through the seamless integration of data and processes, the various organizational units develop a unified view of the business.

More recently, traditional ERP systems are being extended beyond the organization to the ecosystem level that includes network partners and customers (Davenport and Brooks 2004). The functional interoperability provided by extended ERP systems facilitates collaboration with external partners. Additional modules that integrate e-commerce tools supplement traditional ERP systems.

Supply Chain Management Systems. Supply chain management systems are composed of another set of important and prevalent IT tools that have implications for coordination. Supply chain management systems integrate suppliers, manufacturers, distributors, and retail stores, so that merchandise is produced and distributed in the right quantities, to the right locations, and at the right time for minimal systemwide costs (Subramani 2004). These tools facilitate the exchange of information between firms and, in many ways, create the feel of vertical integration between otherwise independent firms (Zaheer and Venkatraman 1994).

IT investments in supply chain management contribute to major changes in business processes, such as the outsourcing of manufacturing and the adoption of complex demand-driven production. For example, the PC industry uses electronic data interchange (EDI) and net enablement to coordinate partners that are primarily independent firms (Dedrick and Kraemer 2005). Using net enablement, Dell pioneered a demand-driven, direct-sales, build-to-order model. This model differs from a traditional supply-driven, build-to-forecast model. Dell's supply chain partners from across the globe participate in assembling systems once the customers choose a configuration (Friedman 2005). Suppliers keep inventory in supply hubs near final assembly plants, and retained ownership of that inventory until it is delivered to the plant for assembly. Highly sophisticated forecasting and planning tools ensure optimum supply of parts without excessive inventory costs. Due, in part, to the broad adoption of supply chain management systems, the PC industry's average for inventory turnover rose from 23.6 turns per year in 1998 to 88.4 turns in 2003. With PC makers coordinating most of their activities with external partners, a broad value network, unbounded by physical proximity, has developed in the PC industry.

In summary, the various IT tools enable greater coordination and collaboration inside and outside firm boundaries. Outside firm boundaries, IT tools reduce the costs associated with search, communications, and coordination with external partners around the globe (Boudreau et al. 1998). However, these tools also enhance coordination within an organization and decrease internal bureaucratic costs leading to a greater internalization of activities and an increase in firm size.

Given IT's potential to enhance both internal and external coordination, what influence will IT investment have on the use of loosely coupled organizational forms such as alliances and contingency workers? When looking at IT investment in a vacuum, its effect on loose coupling is essentially indeterminate. We maintain that the influence of IT on loose coupling depends, in part, on the confluence of the broader industrial context—specifically whether or not there are established industrial standards, the rate of technological change, and the overall diversity in component inputs.

Hypotheses Development

Industry Standards and IT Investment. One of the primary theoretical lenses used to explain firm boundaries is transaction cost economics. The basic premise of transaction cost economics is that firm boundaries are driven by the threat of opportunistic behavior on behalf of contracting parties. Firms adjust their boundaries to reduce such threats. Asset specificity plays a particularly central role for transaction cost logic, and is the extent to which the assets associated with a given contractual relationship can be easily redeployed for alternative uses (Williamson 1985). As asset specificity between two parties increases, it becomes difficult to disentangle those assets from their current deployment and redirect them toward other productive purposes. Asset specificity creates dependency relationships and decreases the ability to readily shift to other potential alliance partners or contingent employees. Because of the high degree of dependency, any changes that require negotiation may lead to *hold up*, whereby one party can take advantage of the situation. To contend with this potential for opportunism, contracting parties would need to put in place extensive contingency clauses, elaborate incentives, and monitoring mechanisms, thereby increasing costs and decreasing flexibility. Thus, asset specificity makes loosely coupled relationships particularly problematic.

Industry standards are one mechanism that reduces the level of asset specificity between contracting partners. Standards may emerge through ad hoc market mechanisms (such as voluntarily adopted uniform employment policies and shared groupware platforms) or may be formally negotiated by industry trade associations or standards organizations. Examples of such standards organizations include the International Telecommunication Union, the Institute of Electrical and Electronics Engineers among others (Hawkins 1999). Firms negotiate the content of technical specifications to ensure that components provided by any compliant manufacturer will interconnect with complementary products from other manufacturers. Standards-developing organizations most frequently develop anticipatory standards, which are pre-competitive and set the stage for competition *within* rather than between technologies. Standards organizations may also, however, be formed to shape and govern standards that have emerged de facto. Many, if not most, standards-developing organizations are composed of corporate voting members (ANSI 2004).

Such standards facilitate the use of loosely coupled relationships by codifying and standardizing key manufacturing technologies and processes (Schilling and Steensma 2001, Sturgeon 2002). For example, the *ANSI/AGMA/AWEA 6006-A03 Design and Specification of Gearboxes for Wind Turbines Standard* provides information for specifying, selecting, procuring, designing, manufacturing, and operating reliable speed-increasing gearboxes for a wind turbine generator service. When firms adhere to this standard, it is much easier for multiple producers to cooperatively develop, manufacture, or operate wind turbine systems. Compatibility and quality of components are more easily ensured when each firm conforms to a common set of design, manufacturing, and operating specifications. Standards can also regulate the training and certification of personnel that will perform key tasks. Personnel certification standards make it easier to use contingent workers by providing a verifiable measure of a contingent worker's skill set, as well as a common technical language that is not firm specific.

Standards reduce asset specificity by making resources nonspecific to a particular exchange. With the emergence of multiple capable partners in the market, the potential hazard of "locking in" between firms is reduced (David and Greenstein 1990). Industry standards decrease a firm's incentive to integrate a broad range of activities within the firm. In short, industry standards provide an opportunity for organizations to pursue loosely coupled organizational forms such as alliances and contingent workers.

Industry standards and IT investment are mutually supportive with respect to their influence on loose coupling. By reducing asset specificity, industry standards provide the opportunity to derive flexibility through loosely coupled relationships. IT investment and the resulting coordination capabilities enable firms to more readily exploit such opportunities for flexibility. When industry standards exist, the coordination capabilities resulting from IT investment can be targeted toward external partners to facilitate loose coupling. Thus, as IT investment increases in an environment with standards, the pursuit of loose coupling will also increase.

When standards do not exist, the opportunity for loose coupling will be diminished because of higher levels of asset specificity. Under such conditions, the relationships between IT investment and loose coupling will be relatively weak. When there are no industry standards, the coordination capabilities resulting from IT investment will be targeted more inward and less toward external partners. IT investment will be more strongly associated with loosely coupled organizational forms when industry standards exist than when industry standards do not exist.

Hypothesis 1. *There will be a stronger positive relationship between industrywide IT investment and the use of loosely coupled organizational forms when industry standards exist as compared to when industry standards do not exist.*

Technological Change and IT Investment. Industries vary in terms of the extent to which predictions can be made about the future. Some industries are inherently more stable than others. Uncertainty about the future may be a source of inefficiency when establishing business relationships with outside parties (Pisano 1990). An environment fraught with uncertainty makes it difficult to write, execute, and monitor contractual arrangements (Leiblein and Miller 2003, Walker and Weber 1987, Williamson 1985).

A primary source of uncertainty is *technological change*. Technological change is the speed in which the underlying technology supporting the value being offered by an industry varies. Technological change disrupts the underlying equilibrium of an industry (Schumpeter 1942) and can potentially render existing firm resources obsolete (Henderson and Clark 1990). When technology is changing rapidly, the firm may be uncertain about customer needs, the likely dominant design, and which inputs to use.

Under conditions of high uncertainty, specifying contracts to form alliances and hire contingent workers may be challenging. When product architectures are shifting and when customer demand is uncertain, establishing complete contracts that take into account the various contingencies may be difficult. As a result, the combination of technological change and alliance formation or the use of contract workers can lead to a series of renegotiations as the uncertainty becomes resolved over time (Pisano 1990). Each time negotiations occur, the parties to the contract open themselves to the self-serving behavior of the other party. The potential for self-serving behavior leads to intensive monitoring and possible legal recourse, which, in turn, generates transaction costs and inefficiency. Thus, according to transaction cost economics, high rates of technological change will make loosely coupled relationships problematic and will provide pressure on firms to avoid loose coupling by internalizing activities.[3]

IT can facilitate the firm's response to this pressure. Broadly integrated firms require strong internal coordination to be effective. IT promotes faster, more accurate, and better-coordinated information flow across key business functions, business divisions, and geographical regions (Gurbaxani and Whang 1991). With a streamlined IT infrastructure, a central decision maker can coordinate a broad range of activities within the hierarchy avoiding information overload (Bolton and Dewatripont 1994).

The combination of technological change and IT investment influences the level of loose coupling. When uncertainty is low, loose coupling and its associated flexibility is a more viable opportunity for firms. The coordination capabilities resulting from IT investment can be targeted toward external partners to facilitate such opportunities. Thus, as IT investment increases in an environment with low technological change, the pursuit of loose coupling will also increase.

When uncertainty is high, loose coupling becomes less viable because of the potential for transaction costs. Under such conditions, the relationships between IT investment and loose coupling will be relatively weak. Coordination capabilities resulting from IT investment will be targeted less toward external partners and more inward to effectively avoid loose coupling.

HYPOTHESIS 2. *There will be a stronger positive relationship between industrywide IT investment and the use of loosely coupled organizational forms when there are low levels of technological change as compared to when there are high levels of technological change.*

It is important to note, however, that the extent to which uncertainty in the form of technological change generates transaction costs depends, in part, on the level of asset specificity (Williamson 1985). Despite the fact that transaction cost logic argues that the *combination* of uncertainty and asset specificity influences firm boundaries, most studies overlook this higher order specification and merely consider the simple effects (David and Han 2004).

When asset specificity is generally low (i.e., when there are industry standards), the combination of technological change and loosely coupled relationships may not necessarily lead to an increased potential for opportunism and transactions costs. Partners can readily contend with an uncertain future when asset specificity is trivial (Williamson 1985). Adapting external relationships to a changing environment is relatively easy when the value creating potential of the parties' assets is not tightly intertwined. Despite the uncertainty, the limited asset specificity still allows for the possibility of switching partners. Market competition remains intact, thereby limiting haggling and opportunism.

In contrast, when asset specificity is high (i.e., no standards exist), a stable future is particularly critical for the formation of loosely coupled organizational forms. In the presence of high asset specificity, high levels of uncertainty will lead to constant haggling and increase the relative attractiveness of internalizing the activity. Moreover, when asset specificity is high and the environment is stable, loosely coupled relationships may not necessarily pose a problem. A durable dependency relationship can be successfully facilitated because the need to adapt will be limited because of stability.

Thus the influence of technological change on the level of loose coupling will depend on whether or not there are industry standards. Likewise, the influence of IT on the use of loosely coupled organizational forms will depend, in part, on this interaction between technological change and industry standards. When there are industry standards, the contractual difficulties because of high levels of technological change are tempered. Arguably, the ideal environment for loose coupling is when technological change is limited *and* industry standards exist. Under such conditions, the opportunity to pursue flexible, loosely coupled organizational forms will be optimal. Industrywide IT investment and the resulting coordination capabilities will enable firms to exploit this opportunity. The relationship between IT investment and loose coupling will be relatively strong in environments with low levels of technological change and industry standards.

When there are no industry standards, technological change leads to contractual hazards, providing pressure for firms to avoid loose coupling. Loose coupling will be particularly unattractive under conditions of high technological change and no industry standards. Under such conditions, the relationships between IT investment and loose coupling will be relatively weak. The coordination capabilities resulting from IT investment will be targeted more inward and less toward external partners to effectively avoid loose coupling.

HYPOTHESIS 3. *The relationship between industry-wide IT investment and the use of loosely coupled organizational forms will be strongest when there are low levels of technological change and industry standards exist.*

HYPOTHESIS 4. *The relationship between industry-wide IT investment and the use of loosely coupled organizational forms will be weakest when there are high levels of technological change and industry standards do not exist.*

Input Diversity and IT Investment. Industries vary in the general complexity of production. In some industries, production entails combining a wide range of different inputs (e.g., automobiles, consumer electronics, appliances, etc.). Other industries have much simpler production processes (e.g., logging, primary aluminum, raw cane sugar, etc.). The diversity of inputs inherent in an industry will influence firm boundaries, although the manner of doing so is not straightforward. There are two faces to the influence of input diversity on the pursuit of loose coupling.

From a modular systems perspective, the flexibility of a modular system enables multiple configurations from a given set of inputs (Schilling 2000). Thus, as the variety of inputs increases, so does the number of potentially valuable configurations that can be created from the inputs—if the system has the necessary flexibility to reconfigure inputs. Thus the value of flexibility increases as input diversity increases. Loosely coupled forms are one means to gain necessary flexibility to create varied configurations. For example, biotechnology firms make extensive use of network relationships to access diverse knowledge to create new combinations of products (Powell et al. 1996).

A broad diversity of inputs in a production system also tends to lead to differentiated capabilities across firms (Barney 1991). Some firms will gain a competitive advantage through specific inputs and associated activities. Under such conditions, firms have a tendency to specialize in core activities and rely on loosely coupled relationships to create new configurations (Schilling and Steensma 2001). In sum, diversity in terms of inputs provides pressure to rely on loosely coupled organizational forms.

However, diversity also makes external relationships difficult to manage (Skaggs and Huffman 2003, Ulrich and Ellison 2005). When there are a lot of moving parts to production, the firm becomes susceptible to underspecified contracts and tenuous relationships. Establishing tight contracts that take into account all contingencies becomes increasingly difficult as the number of inputs grows. The potential for exceptional cases creates uncertainty. In highly complex environments, feasible designs are often established through trial and error and unstructured dialogue between production process experts and component designers (Monteverde 1995). It is more difficult to hold unstructured technical dialog with the outside parties than it is within the firm. Monitoring the quality of the numerous inputs used by a partner firm also becomes more onerous as there are more occasions where subpar materials can be used. Because of such contractual hazards, greater diversity of inputs provides pressure to avoid loose coupling.

Thus the general influence of input diversity on organizational forms differs depending on whether viewed through a modular systems (increases loose coupling) or a transaction costs (increases tight coupling) theoretical lens. The availability of industry standards assists in sorting out these contradictory effects. Standardization, in general, tempers contractual complexity (Jones et al. 1997) and makes input diversity more manageable. Standards typically establish quality requirements and specifications as to how the inputs are put together. Although there may be a high number of production inputs, contracting with external parties becomes easier when standards exist. In essence, industry standards reduce the uncertainty because of input diversity and provide a foundation on which a relationship can be based. Thus the influence of input diversity on the level of loose coupling will depend on whether or not there are industry standards. When industry standards do not exist, high levels of input diversity will make loose coupling particularly problematic because of the potential for transaction costs. However, when standards do exist, firms will be more apt to pursue the flexibility derived from loose coupling in response to higher levels of input diversity.

Likewise, the influence of IT on the use of loosely coupled organizational forms will depend, in part, on this interaction between input diversity and industry standards. When there are industry standards, the contractual difficulties because of input diversity are tempered. Input diversity provides pressure on firms to specialize in core activities and use loosely coupled organizational forms to derive flexibility. IT investment further facilitates loosely coupled organizational forms by providing needed external coordination and communication. The relationship between IT investment and loose coupling will be particularly strong in environments with high levels of input diversity and industry standards.

Loose coupling will be particularly unattractive when there are no industry standards and a highly diverse set of inputs because of the potential for transaction costs. The coordination capabilities resulting from IT investment will be targeted inward more so than when industry conditions are more favorable for loose coupling, resulting in a particularly weak relationship between IT investment and loose coupling.

HYPOTHESIS 5. *The relationship between IT investment and the use of loosely coupled organizational forms will be strongest when there are high levels of input diversity and industry standards exist.*

Hypothesis 6. *The relationship between IT investment and the use of loosely coupled organizational forms will be weakest when there are high levels of input diversity and industry standards do not exist.*

Methods

We gathered data on every U.S. manufacturing industry at the 4-digit standard industrial classification (SIC) level. After eliminating those industries for which data are not available for every variable (some 4-digit industries have so few firms that data for them are not reported), we were left with 366 industries for models predicting alliance formation and 444 industries for models predicting the use of contingent workers.

Dependent Measures

We view contingent workers and alliances to be two distinct means by which a firm can access expertise from outside of its normal boundaries. By assessing the use of two loosely coupled organizational forms, the empirical results for the two forms can be compared and contrasted.

Contingent Workers. To measure the use of contingent workers, statistics on employment in contingent work arrangements as a percentage of total employment in that industry (four-digit SIC level) were obtained from an unpublished study conducted by the Bureau of Labor Statistics.[4] These reports were from a supplement to the February 1997 *Current Population Survey* of 50,000 households and included statistics on several different types of work arrangements. The two arrangements that were most explicitly contingent, and thus most closely demonstrated loose coupling are contract agency workers and temporary help agency workers. *Contract agency workers* (those who work for a contract company and who generally work for only one customer at the customer's work site) were clearly temporary, with average job tenures that were less than those of individuals in traditional employment arrangements (Cohany 1998). Contract agency workers were likely to have professional or technical service jobs. *Temporary agency workers* (those who are paid by a temporary help agency) were similar to contract agency workers in that they were also temporary, with average job tenures that were less than those of individuals in traditional employment arrangements. Temporary agency workers, however, were more likely to be in clerical, labor, construction, and food service jobs. On average, temporary agency workers were younger, less educated, and less likely to receive benefits coverage. There are no overlaps in these categories; workers classified as being in contingent work force were counted only in the category in which they best fit. Percentage-based variables for each industry were created by dividing employment in each contingent work arrangement by total employment in that industry. This captures the degree to which the industry relies on each particular type of contingent work arrangement. These measures were aggregated to create an overall value for the use of contingent workers.

Alliance Formation. Data on strategic alliances were gathered from Securities Data Company's Joint Venture and Strategic Alliances Database. This database provides the primary SIC code of each partner in each alliance, which enabled us to form counts of alliances by industry. We then divided the alliance counts by number of firms in the industry to get a measure of degree of alliance formation for each industry. Consistent with contingent workers, we used data on alliances formed in 1997.

Independent Variables

IT Investment. To measure IT intensity for each industry, we used the digital economy data developed and used by the Bureau of Economic Analysis (BEA) for the year 1996. This metric is based on the total value of IT equipment per full-time employee.[5] IT equipment includes computers and peripheral equipment, software, and other information-processing equipment. The ratio for each industry is normalized by dividing through by the ratio of IT equipment per full-time employee for all industries. Thus an industry with a ratio exceeding 1 is more IT intensive than average. An industry with a ratio below 1 is less IT intensive than average.

Input Diversity. To measure input diversity for each industry, we used the 1997 Benchmark Input Output data.[6] These tables provide data on every commodity category input used by an industry. We used counts of every commodity category used by that industry. In a study of the construct validity of various measures of diversification, Lubatkin et al. (1993) found that a simple count of the number of SIC codes that the firm operates captured diversification as well as any of the weighted measures commonly used. Though our counts are not for measuring diversification, an analogous argument can be applied that counts of commodity classes used by firms should capture the diversity of inputs. We divided this measure by 100 for easier interpretation of the regression coefficients.

Availability of Standards. To capture whether standards are available in the industry, we used the database of standards organizations provided by the American National Standards Institute (ANSI). A dummy variable $(0, 1)$ was employed to indicate whether the industry has a registered member of the ANSI that develops and administers standards for that industry.

Technological Change. Similar to Schilling and Steensma (2001), we measured technological change using the growth in total factor productivity (TFP). TFP growth is a version of the Solow (1957) residual and measures industry-level rates of technological change.

A series of studies of economic growth conducted at the National Bureau of Economic Research (NBER) showed that the historic rate of economic growth in gross domestic product (GDP) could not be accounted for entirely by growth in labor and capital inputs. A consensus has emerged that the residual largely captured technological change (Terleckyj 1980), and a number of researchers have used TFP growth at the industry level (e.g., Jorgenson 1984, Schilling and Steensma 2001, Siegel and Griliches 1991). The Bartelsman-Gray manufacturing productivity database tracks TFP growth for every four-digit manufacturing SIC code from 1958–1994. This measure is based on a five-factor production function: capital, production worker hours, nonproduction workers, non-energy materials, and energy. The TFP growth index is calculated as the growth rate of output (real shipments) minus the revenue-share-weighted average of the growth rates of each of the five inputs (Bartelsman and Gray 1996). The measure used in this study is the average TFP growth rate (as reported in the Bartelsman-Gray database) from 1990–1994 at the four-digit SIC level.

Control Variables

We included four control variables to isolate the effects of interest. We control for *industry size* in terms of the number of firms in each industry. We acquired this data from the *U.S. Census Bureau CenStats Database*. As the number of firms increase, there may be greater opportunity to form partnerships. We also control for *industry munificence* in terms of growth in sales. Growth in demand may encourage the use of alliances and contingency workers as firms contend with such growth. Following the methodology employed by Keats and Hitt (1988), we acquired industry sales for the years 1992–1996 from the *U.S. Census Bureau Annual Survey of Manufacturers*. The natural logarithms of these sales figures were entered into quasi-time series regressions with time serving as the independent variable. The antilogs of the resulting regression slope coefficients were then used to capture industry growth. Finally, we controlled for *average firm size* and the *competitive intensity* of the industry. Average firm size in terms of assets was based on data from NBER. To measure competitive intensity within each industry, we used the inverse of the four-firm concentration ratio obtained from the *U.S. Census of Manufacturers* for 1992 (the most recent year for which the data are available).

Results

Table 1 reports the variable means, standard deviations, and correlation coefficients between the dependent and independent variables. We used hierarchical moderated linear regression models to examine the hypothesized moderating effects. Each subsequent model builds on previous models with the addition of variables.

Table 2 reports the results of the hierarchical moderated regression models. To enhance interpretation and limit the correlation between the lower order and higher order variables, we centered all variables that make up the interaction terms (Aiken and West 1991). A separate series of regression models was generated for each of our two dependent variables. Multicollinearity diagnostics indicated that multicollinearity would not adversely influence the regression models (Tabachnik and Fidell 2001).

In Models 1(a) and 1(b) of Table 2, we entered the control variables and main effects of our independent variables. In general, for our sample of industries, IT investment has a positive relationship with both the use of alliances ($p < 0.001$) and contingent workers ($p < 0.001$).

Hypothesis 1 proposes that the relationship between IT investment and the use of loosely coupled organizational forms will depend, in part, on the existence of industry standards. Specifically, IT investment is posited to have a stronger positive effect on the use of loosely coupled organizational forms for industries having industry standards. Models 2(a) and 2(b) of Table 2 add the hypothesized two-way interaction terms between IT investment and the other industry context variables. As a set, they significantly improve on Models 1(a) and 1(b) (direct effects only) across both dependent variables

Table 1 Intercorrelation Matrix for Dependent, Independent, and Control Variables

Variables	Mean	S.D.	1	2[a]	3	4	5	6	7	8	9
1. Alliance formation	0.11	0.23									
2. Contingent workers[a]	0.02	0.02	0.16**								
3. Industry size	944.06	2,252.71	−0.09	−0.05							
4. Industry munificence	1.06	0.05	0.11*	0.18**	0.03						
5. Average firm size	6.33	11.18	0.56**	0.27**	−0.12	0.05					
6. Competitive intensity	0.04	0.06	−0.13*	−0.04	0.69**	0.08	−0.15**				
7. IT investment	0.83	1.02	0.26**	0.33**	−0.04	0.06	0.16**	−0.06			
8. Industry standards	0.58	0.49	0.15**	0.12*	−0.14	0.05	0.09	−0.07	0.09		
9. Technological change	0.01	0.02	0.15**	0.04	−0.06	0.12*	0.13*	0.00	−0.04	0.08	
10. Input diversity	0.66	0.62	0.07	0.12*	0.08	0.18**	0.14**	0.06	0.16**	0.05	0.01

[a]$N = 444$, *$p < 0.05$, **$p < 0.01$.

Table 2 Hierarchical Moderated Regression Models for Loosely Coupled Forms[a]

	Alliance formation			Contingent workers		
Variables	Model 1(a)	Model 2(a)	Model 3(a)	Model 1(b)	Model 2(b)	Model 3(b)
Constant	−0.29	−0.17	−0.16	−0.045	−0.037	−0.032
Control variables						
Industry size	0.00	0.00	0.00	0.000	0.000	0.000
Industry munificence	0.32†	0.22	0.21	0.061***	0.054**	0.049**
Average firm size	0.01***	0.01***	0.01***	0.001***	0.001**	0.001**
Competitive intensity	−0.28	−0.24	−0.26	0.007	0.022	0.025
Direct effects						
IT investment	0.04***	0.05***	0.04***	0.005***	0.004***	0.006***
Industry standards	0.04†	0.05*	0.06**	0.002	0.004*	0.001
Technological change	0.79†	1.09†	1.07†	0.019	0.092†	0.087†
Input diversity	−0.02	−0.02	−0.01	0.001	0.001	−0.002
Two-way interactions						
Industry standards × IT investment		0.06***	0.09**		0.011***	0.007**
Technological change × IT investment		−0.37	−0.42		−0.121***	−0.081*
Input diversity × IT investment		−0.07***	−0.04†		0.003*	−0.003
Technological change × industry standards		0.31	0.46		0.287***	0.239**
Input diversity × industry standards		−0.01	−0.03		0.001	0.005
Three-way interactions						
Tech. change × industry standards × IT investment			0.15			−0.167*
Input diversity × industry standards × IT investment			−0.09†			0.016**
R^2	0.37***	0.42***	0.42***	0.42***	0.52***	0.54***
ΔR^2		0.05***	0.00		0.10***	0.02**

[a] $N = 366$ for alliances, $N = 444$ for contingent workers; $^†p < 0.1$, $^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

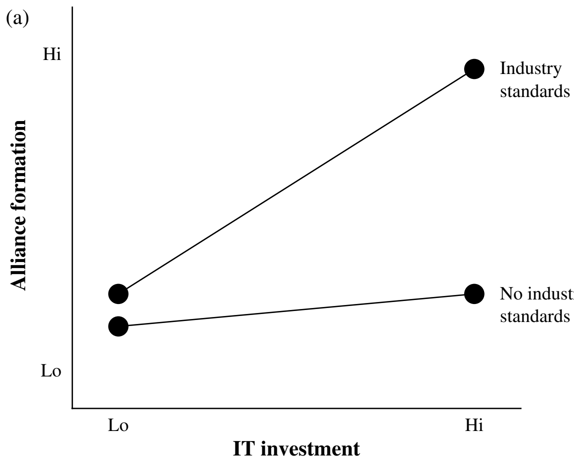
as indicated by the change in the R^2 ($p < 0.001$). Moreover, the coefficient for the industry standards interaction is significant and positively signed for both alliance formation and contingency workers ($p < 0.001$).

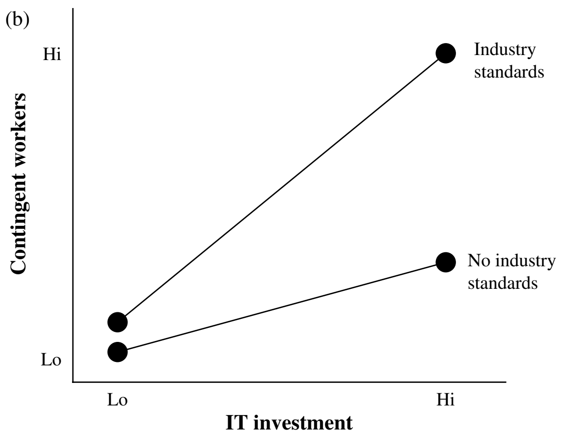
To further explore the nature of these relationships, we plotted the significant interactions using one standard deviation above and below the mean of IT investment and at 0 (i.e., no standards) and 1 (i.e., standards exist) for the industry standards variable (Figures 1(a) and 1(b)). As predicted, IT investment has a stronger positive influence on both alliance and contingent worker use when industry standards exist as compared to when industry standards do not exist. Specifically, a one standard deviation increase from the mean in IT investment led to a 22% increase in the use of contingency workers when there were no standards, and a 138% increase when there were standards. Similarly, a one standard deviation increase from the mean in IT investment led to a 4% increase in the use of alliances when no standards existed, and a 92% increase when standards existed. Thus, Hypothesis 1 is supported.

In Hypothesis 2, we argue that IT investment will be more positively related to the use of loosely coupled organizational forms for those industries that have low levels of technological change as compared to industries with high levels of technological change. The interaction term involving technological change and IT investment is significant for contingent workers ($p < 0.01$), but not for alliance formation Table 2, Models 2(a) and 2(b). A more positive relationship between IT investment and the use of contingent workers exists when technological change is low as compared to when technological change is high. Specifically, a one standard deviation increase from the mean in IT investment led to a 52% increase in the use of contingency workers when technological change was high, and a 63% increase when technological change was low. There is partial support for Hypothesis 2 for the use of contingent workers.

Hypotheses 3 and 4 contend that the relationship between IT investment and the use of loosely coupled organizational forms depends, in part, on the joint effect of technological change and industry standards. Models 3(a) and 3(b) (Table 2) add the associated three-way interaction terms hypothesized. The change in R square was significant for contingent workers ($p < 0.01$), but not for alliances. The interaction term associated with technological change, industry standards, and IT investment was positive and significant ($p < 0.01$). We plotted this significant three-way interaction in Figure 2. As predicted in Hypotheses 3, the relationship between IT investment and contingent workers is most strongly positive when levels of technological change are low and industry standards exist. In contrast, the relationship between IT investment and contingent workers is weakest when levels of technological change are high and industry standards do not exist (Hypothesis 4). Specifically, a one standard deviation increase from the mean in IT investment led to an 11% increase in the use of

Figure 1 The Interaction Between Industry Standards and IT Intensity





contingency workers when there was high technological change and no standards existed, and a 282% increase when there was low technological change and standards existed.

Hypotheses 5 and 6 contend that the relationship between IT investment and the use of loosely coupled organizational forms depends, in part, on the joint effect of input diversity and industry standards. Models 3(a)

Figure 2 The Interaction Between Technological Change, Industry Standards, and IT Intensity

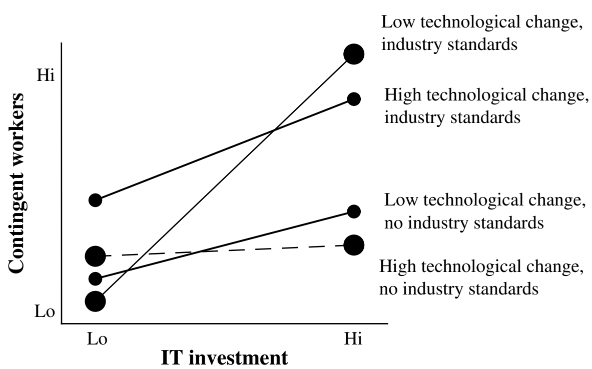
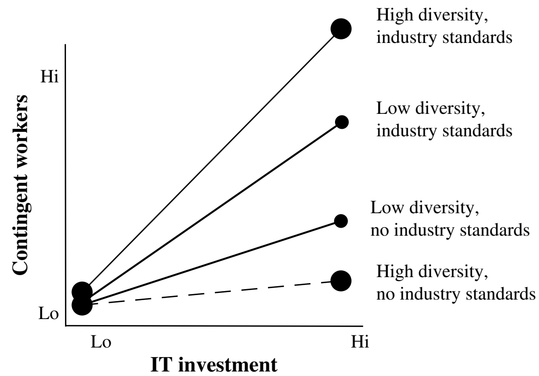


Figure 3 The Interaction Between Input Diversity, Industry Standards, and IT Intensity



and 3(b) (Table 2) add the associated three-way interaction term. This term was significant for contingent workers ($p < 0.001$). We plotted the significant three-way interaction in Figure 3. As predicted in Hypotheses 5, the relationship between IT investment and contingent workers is strongest when there are high levels of input diversity and industry standards exist. In contrast, the relationship between IT investment and contingent workers is weakest when levels of input diversity are high and industry standards do not exist (Hypothesis 6). Specifically, a one standard deviation increase from the mean in IT investment led to a 13% increase in the use of contingency workers when input diversity was high and industry standards did not exist. In contrast, a standard deviation increase in IT investment led to a 20-fold increase in the use of contingency workers when input diversity was high and industry standards exists.

Though not hypothesized, the two-way interaction between input diversity and IT investment was significant for the alliance use dependent variable (Model 2a). We find that the relationship between IT investment and the use of alliances is more strongly positive when levels of input diversity are low as compared to when levels of input diversity are high.

Discussion

Does IT investment lead to more loosely coupled organizational forms (Hitt and Brynjolfsson 1997)? In this study, we sought to better understand the influence of IT on loose coupling. We argue that IT investment promotes both loose coupling and tight integration by providing strong coordination both within the firm and between a firm and its partners outside of the firm. Using transaction cost and modular systems logic, we suggest that the nature of the relationship between IT and organizational forms depends, in part, on industry contextual factors. Overall, we find that industrywide IT investment is associated with loosely coupled forms only when industry conditions are particularly conducive.

Specifically, we find that when industry standards exist, IT investment leads to greater use of both alliances and contingent workers. When industry standards do not exist, IT investment does not appear to have any influence on the use of these loosely coupled organizational forms. We argue that industry standards reduce asset specificity that hampers external relationships and provide an opportunity for firms to gain flexibility via loose coupling. As loose coupling becomes more viable because of reduced asset specificity, external coordination capabilities of IT facilitate the use of loosely coupled forms.

Our results suggest that IT investment has a stronger positive relationship with the use of contingent workers when levels of technological change are low as compared to when levels of technological change are high. We argue that technological change generally renders loosely coupled relationships problematic because of uncertainty and transaction costs. When technological change is limited, gaining flexibility via contingent workers is increasingly viable. IT further facilitates the use of contingent workers by providing necessary external coordination capabilities. When there is relatively high technological change, IT does not appear to influence the use of contingent workers.

We considered a more complex model by exploring how the joint effect between technological change and industry standards alters the influence of industrywide IT investment on firm boundaries. Conditions are particularly ripe for loosely coupled organizational forms when levels of technological change are low and industry standards exist because the potential for transaction costs are limited. Under such conditions, we find that industrywide IT investment has the strongest positive relationship with the use of contingent workers. The external coordination capabilities resulting from IT investment can facilitate the pursuit of flexible loose coupling via contingent workers.

In contrast, when levels of technological change are high *and* industry standards do not exist, the potential for transaction costs are particularly high. Under such conditions, we found increasing IT investment has the weakest influence on the use of contingent workers. We suggest that the coordination capabilities resulting from IT investment are being targeted more internally and less externally.

We also considered how the joint effect between industry standards and input diversity changes how IT investment influences firm boundaries. When there are high levels of input diversity *and* industry standards exist, we found that IT investment led to an increased use of contingent workers. We argue that input diversity provides pressure on firms to become modular, specialize in a core set of activities, and rely on loosely coupled organizational forms to create flexible configurations (Schilling and Steensma 2001). Industry standards temper the contractual difficulties that arise from input diversity and enable firms to pursue loosely coupled forms. Under such conditions, IT investment further facilitates the use of contingent workers by providing capabilities to effectively coordinate external partners.

However, we find that when there are high levels of input diversity *and* industry standards do not exist, industrywide IT investment had no influence on the use of contingent workers. We maintain that although input diversity promotes loose coupling, it also creates contractual hazards, because such diversity makes accounting for all the possible contingencies and exceptions difficult (Skaggs and Huffman 2003, Ulrich and Ellison 2005). Moreover, when industry standards do not exist, there is no mechanism to temper the uncertainty in contracting resulting from input diversity. Despite the enhanced coordination capabilities, industrywide IT investment is unable to increase the use of contingent workers.

There were some differences between our models for alliances and contingent workers. Overall, the joint effects involving IT and technological change had a greater influence on the use of contingent workers than on alliance formation. Technological change appears to only influence alliance formation in a positive and direct fashion ($p < 0.1$, Table 2, Model 1(a)). The influence of uncertainty on alliance formation appears to be more consistent with an options logic, which suggests that when uncertainty is high, firms pursue loosely coupled forms to buffer against such uncertainty (Folta and Miller 2002). However, our analysis also suggests that IT investment leads to higher levels of alliance formation when levels of input diversity are low as compared to when they are high. These results suggest that, in the case of alliance formation, the contractual difficulties because of input diversity are relatively more influential than the pressure to specialize because of input diversity. Transaction cost logic appears to be more applicable in explaining the influence of input diversity on alliance formation than does modular systems logic.

Our findings are consistent with a number of case studies. One example is that of the computer industry. During the early stages of this industry, standards had not yet evolved, technological uncertainty was prevalent, and production design in terms of inputs was relatively complex. The PC design was based on interdependent or tightly coupled architectures. Although the computer industry was on the forefront in its use of IT (e.g., electronic data exchange), loosely coupled relationships were limited. Since the 1990s, industry standards have evolved. The PC industry has been able to exploit its IT investment and become increasingly disaggregated as both upstart firms like Dell and traditional firms like IBM are pursuing more loosely coupled forms of organization (Dedrick and Kraemer 2005).

The auto industry provides another example. U.S. auto engineers designed standards and modular production systems as far back as 1914 (Starr 1965, Swan 1914). However, it was not until the onset of the IT revolution in the 1990s that modular networks and shared platforms occurred among U.S., European, and Asian automakers (Shimokawa 1999). This combination of IT capabilities and standardization has led to an unprecedented number of alliances in the auto industry, making it increasingly disaggregated as well as global (Shimokawa 1999).

Implications and Extensions

Our research complements the work of others examining similar questions. Afuah's (2003) transaction cost-based theoretical model also suggests that Internet technology can lead to an increase in hierarchy or a greater reliance on market relations, depending on various contingencies. Although Afuah (2003) focuses on a make versus buy dichotomy to keep his theoretical model tractable, he suggests that scholars consider different governance mechanisms, including alliances and partnerships, and assess the role of IT and industry context in the adoption of these governance mechanisms. We extend Afuah's (2003) efforts by empirically assessing the general presumptions put forth in his theoretical work.

Brews and Tucci (2004) conducted a firm-level empirical study of internetworking to examine whether Internet technology promotes external partnering or internal hierarchy. They find that deeply internetworked organizations are more focused, less hierarchical, and more likely to engage in external partnering than less intensively internetworked organizations. Similarly, we find that across all industries, IT investment generally promotes the formation of alliances and the use of contingency workers. Although compelling, Brews and Tucci (2004) did not account for contingencies that may alter the relationship between IT and firm boundaries, as suggested by Afuah (2003) and our analysis. Considering industry context provides a more complete picture.

Our results also provide some insight into the generally mixed results regarding the influence of uncertainty on firm boundaries. There are two faces to the influence of uncertainty. From a transaction cost perspective, uncertainty promotes internalization. Such conditions lead to difficult renegotiations and monitoring such agreements can be unduly costly. The firm opens itself up to opportunistic behavior. Others (e.g., Bowman and Hurry 1993, Folta and Miller 2002) have used real options logic to argue that uncertainty promotes external partnerships. Firms will benefit from forming external relations under conditions of high uncertainty because external relations are more flexible than hierarchy, and such flexibility is particularly valuable during times of change.

David and Han's (2004) recent meta-analysis highlights this point of contention. According to their compilation of past research, there is a lack of an empirical consensus on how uncertainty influences firm boundaries. Our results provide some clarification on the effect of uncertainty on firm boundaries. In general, our arguments and results suggest that a direct relationship between uncertainty and firm boundaries may be underspecified. We find that, in the case of contingency workers, the influence of technological change on loose coupling depends on both industry standards and IT investment. Our results integrate both transaction cost and options logic. Consistent with options logic, high uncertainty resulting from technological change leads to the use of contingency workers, but only if there are standards to buffer the potential for transaction costs resulting from such uncertainty. IT investment further increases the use of contingency workers when there are both high uncertainty and industry standards. Continuing to disentangle the influence of uncertainty on firm boundaries by exploring complex interactions would provide critical insight on the applicability of the various theories regarding firm boundaries.

Our analysis was at a relatively macro level. A systemic longitudinal analysis at the firm level could bring new insights on the boundary expansion process and consequent increases in efficiency and profitability (Jacobides and Billinger 2006). Future research exploring how firm differences may influence the relationship between IT investment and firm boundaries would also be fruitful. For example, how might strategy influence IT's effect on firm boundaries? Will IT investment lead to greater loose coupling when firm strategy is focused on low cost or when strategy is focused on differentiation via innovation? How might risk preferences enter into the fray (Steensma and Corley 2001)?

Proponents of resource-based and dynamic capabilities views argue that firm attributes have a major influence on boundary decisions (Barney 1991, Kim and Mahoney 2006). ITs can be a valuable, rare, inimitable, and nonsubstitutable resource for a span of time (Ray et al. 2005). Firms differ both in their choice of specific ITs and their adoption and management of IT resources (Tanriverdi 2006). Future efforts focusing on the heterogeneity of IT tools across firms and its influence on organizational boundaries would be of interest. Researchers could pursue a more nuanced analysis of the influence of specific types of IT on firm boundaries.

Our study was cross-sectional and has the associated limitations. We establish that IT investment, in conjunction with industry conditions, is associated with the use of loosely coupled organizational forms. We believe that exploring these relationships further using longitudinal designs will be valuable.

Relatively little work has been done on the performance implications of firm boundaries (David and Han 2004, Mayer and Nickerson 2005). Future efforts considering how IT, in conjunction with firm attributes and the industry environment, influences the overall performance at firm and industry levels would be of great value. To the extent that our results represent market rationality, they may have some normative implications for when managers may want to invest in IT. For instance, IT expenditures may be particularly valuable for firms that are in industries with standards and want to gain flexibility from loose coupling. Firms may be able to overcome a complex production process in terms of inputs, and create a more loosely coupled organization if there are industry standards, and if they invest in IT. In the industries that are complex in terms of inputs and lack industry standards, IT may be primarily beneficial for internal coordination.

Our results also provide some indication of where the formation of industry standards may be most influential in terms of organizational structure: in industries that have high input diversity and are IT sophisticated. Industry leaders in these environments who have not established standards regimes should consider doing so. Assuming that some of the benefits of flexible, loosely coupled organizational forms funnel down to the consumer, government policymakers may also want to provide encouragement and incentives to create standards regimes in these types of industries.

Acknowledgments

The authors thank the special editors, reviewers, David Hekman, and seminar participants at Washington State University and the University of Utah for their insights on earlier versions of the manuscript.

Endnotes

[1]IT investment, broadly defined, includes investments in both computers and telecommunications and in related hardware, software, and services (Dumagan and Gill 2002).

[2]Most of the ERP systems are packaged software applications from vendors such as SAP, Oracle, PeopleSoft, and J. D. Edwards that connect and manage information flows within and across complex organizations.

[3]Notably, a competing argument can be made from an options perspective: High rates of change may encourage the firm to avoid large investments in fixed assets that can become a source of rigidity or excess capacity, leading the firm to prefer loosely coupled arrangements. We consider this possibility in our discussion.

[4]The Bureau of Labor Statistics uses the *Classified Index of Industries and Occupations* rather than the *SIC* system. The conversions to 4-digit SIC were made according to the Census Bureau's *Classified Index of Industries and Occupations*, 1990 CPH-R-4 document.

[5]The BEA calculates this metric as follows: [Investment in IT Equipment for a given industry/Full Time Employees for a given industry]/[Overall Investment in IT Equipment for all industries/Overall Full Time Employees for all industries].

[6]The BEA uses a six-digit industry coding system that is different from both the 1987 SIC system and the NAICS system. Therefore, all BEA industry categories were matched to 1987 SIC codes using the BEA's concordance tables.

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