

EMBEDDED TIES AND THE ACQUISITION OF COMPETITIVE CAPABILITIES

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We build on previous research that explores the external acquisition of competitive capabilities through the embedded ties that firms form in networks and alliances. While information sharing and trust have been theorized to be key features of the interorganizational ties that facilitate the acquisition of competitive capabilities, we argue that these mechanisms provide an incomplete explanation because they do not fully address the partially tacit nature of the knowledge that underlies competitive capabilities. Joint problem-solving arrangements play a prominent role in capability acquisition by promoting the transfer of complex and difficult-to-codify knowledge. Drawing on a set of case studies and a survey of 234 job shop manufacturers we find support for the role of joint problem solving with suppliers in facilitating the acquisition of competitive capabilities. Copyright © 2005 John Wiley & Sons, Ltd.

This research addresses a central question in strategy: how do firms acquire the capabilities they need to develop, sustain, and renew competitive advantage?¹ Though searching for new sources of competitive advantage is a fundamental strategic activity (Rumelt, 1984), there is relatively little systematic research that explains the *sources* of firms' competitive capabilities. Rather, the bulk of research focuses on the performance-related outcomes of capabilities (e.g., Lieberman, Lau, and Williams, 1990; Clark and Fujimoto, 1991; Henderson and Cockburn, 1994). Most of the research that has been done on the genesis of capabilities concentrates on sources internal to the firm. For

instance, Penrose's (1959) early writings suggest that capabilities emerge as the unintended consequence of growth and expansion as managers find new uses for surplus resources. Similarly, Chandler (1992) argues that the knowledge and skills underlying capabilities are 'developed by learning through trial and error, feedback and evaluation' as managers solve problems such as launching new products and scaling up production processes. More recent work on the evolution of capabilities (Helfat, 2000) also points to internal sources of firm capabilities. Taken together, this body of work portrays firms as generating capabilities through an incremental and path-dependent (Nelson and Winter, 1982) process of learning from their *own* experiences.

However, some strategy researchers have started to consider how firms derive capabilities externally through interorganizational ties. By participating in ongoing networks of alliances and exchange, they gain access to valuable network resources that aid in the discovery of new opportunities

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¹ We use the term 'acquisition' to refer to the process by which firms learn about, internalize, and take advantage of new capabilities. We do not mean to indicate outsourcing or purchase of capabilities.

(Gulati, 1999). Network resources, unlike a firm's internal material resources, are akin to social capital (Coleman, 1988) in that they inhere in the structure of relations between firms, rather than within the firms themselves. Informational advantages are one form of network resources that have received considerable attention. By participating in interfirm networks, for example, firms learn about the availability of new alliance opportunities (Gulati, 1999; Kogut, Shan, and Walker, 1992). They also access information about the capabilities and trustworthiness of current or potential partners, thereby increasing their capabilities for alliance formation through such networks (Gulati, 1999). Firms can also augment their innovative capabilities through interorganizational ties by using the network to pool knowledge and resources and gather and screen relevant information (Ahuja, 2000). Maintaining a presence in innovation networks further enhances a firm's innovative capabilities by developing and maintaining its absorptive capacity (Cohen and Levinthal, 1990; Powell, Koput, and Smith-Doerr, 1996; Stuart, 1998; Zaheer and Bell, 2005).

This paper builds on previous work by explicitly examining the underlying mechanisms that facilitate the acquisition of competitive capabilities from external sources. Although information sharing and trust are frequently theorized to be central to the acquisition of capabilities through interfirm ties (Ahuja, 2000; Gulati, 1999; Stuart, 1998), the effects of information sharing and trust typically are inferred rather than examined directly. Consequently, how they translate into the acquisition of capabilities is unclear. We maintain that joint problem solving is a key intervening mechanism that links information sharing and trust to the acquisition of capabilities. More specifically, we argue that information sharing and trust provide only a partial explanation of the mechanisms accounting for capability acquisition. Our claim is that since the knowledge underlying capabilities is partially tacit, it is difficult to articulate and transfer, and that joint problem-solving arrangements are a critical mechanism facilitating the acquisition of capabilities because they promote the transfer of tacit knowledge (Uzzi, 1997). By providing a forum for observation, experimentation, and demonstration, joint problem-solving arrangements provide managers with valuable external learning opportunities to draw on during capability acquisition. While information sharing and trust are important

precursors to the acquisition of capabilities through interfirm ties, joint problem-solving arrangements play a more prominent role by promoting the transfer of complex and difficult-to-codify knowledge.

At the same time, we predict that not all embedded ties are equally influential on the acquisition of capabilities. Some embedded ties are more important than others owing to differences in their content (Burt, 1997; Gulati and Westphal, 1999; Podolny and Baron, 1997). In the case of embedded ties with lead customer and supplier firms, we argue that the degree of firm-specific knowledge each type of exchange partner possesses about a focal firm is a critical feature of the relationship. Exchange partners exerting the greatest influence on a firm's acquisition of capabilities are those that are most knowledgeable of a firm's operations and able to reduce uncertainty about how to implement a capability.

In the following section we formalize our predictions by synthesizing research on firm capabilities and integrating it with the literature on embeddedness. We also draw on a set of case studies completed at the outset of the research to inductively derive predictions that go beyond the existing literature. To test our hypotheses we gathered survey data from 234 job shop manufacturers in seven different industries and analyzed these data with structural equation modeling.

THEORY AND HYPOTHESES

Competitive capabilities

Competitive capabilities are the set of organizing processes and principles a firm uses to deploy its resources to achieve strategic objectives (Kogut and Zander, 1992; Grant, 2002). By shaping the ways in which knowledge, skill, and expertise are coordinated and communicated within a firm, capabilities fundamentally determine what the firm can do (Zander and Kogut, 1995). The building blocks of capabilities consist of theories (Guillen, 1995) and frameworks (Porter, 1991), which structure knowledge and organize information. Managerial practices and techniques also are an important component of capabilities (Eccles, Nohria, and Berkley, 1992).

The process of acquiring capabilities is an uncertain one because it may not be clear if the organizational building blocks exist for addressing a

firm's particular problems or achieving its performance objectives. Moreover, a firm cannot be sure that adopting a given theory, framework, practice, or technique will generate the same performance advantages that other firms appear to have achieved (Lippman and Rumelt, 1982). The process through which capabilities emerge can be vague and difficult to reconstruct because it is often based on idiosyncratic, trial-and-error learning. Firms sometimes develop capabilities by accident rather than by planning (Collins and Porras, 1994), with learning occurring from failure as much as from success (McGrath, MacMillan, and Venkataraman, 1995; Sitkin, 1992). Hence, the process through which a particular capability arises can be difficult to identify.

Even if the practices and techniques underlying a capability are explicitly defined, effective implementation may depend on associated know-how and skill in the firm (i.e., complementary assets) that are not articulated. The particular mix of administrative arrangements and resources that exist in an organization and how they have been combined over time influence the costs and benefits of acquiring a capability. Consequently, results hinge on the degree to which new capabilities can be integrated with what the organization already has in place. Since no two organizations are the same, the effects of acquiring theories, frameworks, practices, and techniques are hard to predict beforehand (Dierickx and Cool, 1989) and managers cannot easily assess the value of a capability *a priori*.

Embedded ties and capability acquisition

Confronted with uncertainty about acquiring capabilities, boundedly rational managers engage in problemistic search and make shortcuts in decision making to conserve their limited time and cognitive resources (March and Simon, 1958). Rather than assessing all the costs and benefits, and a complete set of alternatives, managers satisfice (Simon, 1982) by making decisions about capabilities based on information that is good enough given the uncertainties they face and the opportunities they discover. To overcome the uncertainties associated with acquiring capabilities, we argue that managers do not learn about capabilities in isolation. Rather, firms vicariously learn from the insights, experiences, or abilities previously accumulated by linked organizations (Darr,

Argote, and Epple, 1995; Baum and Ingram, 1998; Kraatz, 1998; Ingram and Simons, 1999). Along these lines, Kraatz reports evidence indicative of the role that network ties play in 'mitigating environmental uncertainty and promoting social learning of adaptive responses among linked organizations' (Kraatz, 1998: 622). Similarly, McEvily and Zaheer (1999) found that diversity of contacts within a firm's network, and participation in regional associations, expose the firm to new ideas, information, and opportunities leading to acquisition of capabilities.

The network of interorganizational ties that firms draw on to learn about capabilities consists of not only the diverse contacts managers have with their peers, but also the critical exchange relationships they have with customer and supplier firms. One set of research on the role of exchange partners in interorganizational learning has tended to focus predominantly on knowledge sharing with lead suppliers (e.g., Uzzi, 1997; Dyer and Nobeoka, 2000). Other research has emphasized that lead customers can be a critical source of knowledge leading to innovation (Argote, 1999; Von Hippel, 1988). For instance, auto industry suppliers have improved their capabilities in quality management, just-in-time production and delivery, and product and process innovation by working closely with lead customers that had already developed expertise in these areas (Helper, 1991).

While the literature on interorganizational learning has emphasized the notion that more deeply embedded ties with both suppliers and customers are conducive to acquiring knowledge and capabilities, it has yet to systematically investigate the relative influence of embedded ties with suppliers vs. customers or how different elements of embedded ties affect the acquisition of capabilities. We extend previous research on interorganizational learning by conceptualizing embedded ties as consisting of fine-grained information sharing, high levels of trust, and joint problem solving (Uzzi, 1997) and by relating these three components of embedded ties to the acquisition of capabilities. Though trust and information sharing are important factors in acquiring competitive capabilities, we suggest that joint problem solving occupies an even more prominent role in facilitating capability acquisition (see Figure 1). In our model, information sharing and trust are the preconditions for joint problem solving. They promote a freer exchange of ideas and a more diligent search for

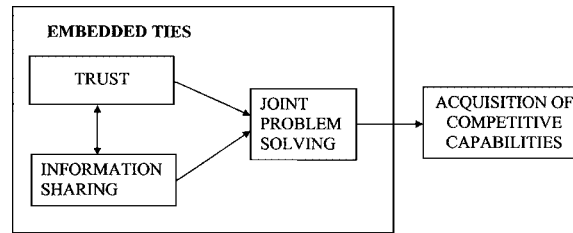


Figure 1. Theoretical model of embedded ties and acquisition of competitive capabilities

solutions, which results in more rapid and effective learning (Jeffries and Reed, 2000). Joint problem-solving arrangements provide learning opportunities by creating a forum conducive to interaction and the transfer of tacit knowledge about capabilities.

Transferring capabilities necessitates 'the acquisition of new know-how, that is, new ways of doing things' (Zander and Kogut, 1995: 78). Yet, the knowledge underlying capabilities is often firm-specific and partially tacit (Polanyi, 1966; Nelson and Winter, 1982). Such knowledge is difficult to codify and articulate, which makes it challenging to transfer (Teece, 1977; Zander and Kogut, 1995; Szulanski, 1996). Rather than being conveyed via written or physical form, idiosyncratic tacit knowledge is best transferred through experience, observation, or demonstration. As Hamel (1991: 99) states, 'complex skills, based on tacit knowledge, and arising out of a unique cultural context may be acquirable only by up-close observation and emulation of "best in class".' Complex skills that involve tacit knowledge and customization to context are promoted by joint problem-solving arrangements that allow exchange partners to engage in experimentation, observation, and search for solutions.

Information sharing and trust also play an important role in capability acquisition, but primarily as precursors. More specifically, information sharing influences managers' awareness of the opportunities available for acquiring beneficial capabilities and trust influences a firm's willingness to accept the advice and recommendations of an exchange partner. Taken together, information sharing and trust indirectly influence capability acquisition by creating the conditions that enable joint problem solving. Without the ability to exchange sensitive and proprietary details about its activities and operations, firms would

find it difficult to engage in joint problem solving. Joint problem solving has a direct influence on capability acquisition by providing an interactive forum for learning that allows firms to observe and experiment with capabilities in practice.

In addition to affecting joint problem solving, information sharing and trust are related to each other, as previous research has established (e.g., Blau, 1960; Boon and Holmes, 1991; Lewicki and Bunker, 1996). While critical, the interaction between information sharing and trust is indirectly related to the acquisition of competitive capabilities and therefore is not the focus of this paper. Recognizing that there are reciprocal effects between information sharing and trust we control for their interaction in our empirical models, but do not offer a theoretical prediction for the relationship.

As the intensity of joint problem solving, information sharing, and trust vary, so too does the level of embeddedness. Accordingly, we do not discretely categorize ties as being either embedded or arm's length, but rather view ties as being arrayed along a continuum anchored by these ideal types. We elaborate the embedded ties constructs further and develop hypotheses that formalize predictions about the effects on the acquisition of capabilities next.

Joint problem solving

To acquire a capability a firm must comprehend it. Joint problem solving is defined as the degree to which the parties to an exchange 'share the responsibility for maintaining the relationship itself and for problems that arise as time goes on' (Heide and Miner, 1992: 275). Such arrangements typically involve routines for troubleshooting problems as they arise and negotiating the mutual adaptations required to resolve the difficulty. Through

joint problem solving, exchange partners develop relationship-specific heuristics and specialized language for conveying complex 'chunks' of tacit knowledge (Hansen, 1999). Such arrangements facilitate the transfer of situation-specific knowledge and, as a result, a firm will be better able to learn about and understand a capability when it has joint problem-solving arrangements in place with exchange partners.

Joint problem-solving arrangements greatly enhance the learning that occurs in exchange relationships because, rather than exiting the relationship when a problem arises, the parties work through the difficulty and receive direct feedback about activities and operations. This kind of interactive relationship is particularly important for the transfer and development of capabilities. Since no two firms are identical, acquiring a capability from an exchange partner requires that it be customized for the focal firm's unique circumstances and adapted to fit with its existing portfolio of capabilities. Two-way interaction is also important for transferring the tacit knowledge underlying a capability since the recipient rarely assimilates the knowledge completely in a single interaction, but requires multiple interactions. By providing a forum where exchange partners can observe, experience, and demonstrate the use of a capability in practice and receive feedback, joint problem-solving arrangements allow a firm to draw on the insights, experience, and ability that customer and supplier firms have with a capability. Accordingly, we hypothesize:

*Hypothesis 1: Joint problem solving with lead **suppliers** is positively related to acquisition of competitive capabilities.*

*Hypothesis 2: Joint problem solving with lead **customers** is positively related to acquisition of competitive capabilities.*

Information sharing

For joint problem solving to occur, it is necessary for the exchange partners to share information relevant to the problem. Information sharing captures 'the degree to which each party discloses information that may facilitate the other party's activities' (Heide and Miner, 1992: 275). As ties become more embedded, information sharing tends to be more detailed, intricate, and proprietary than

in arm's-length relationships in which only basic price and quantity data are shared. Profitability, production cost data, strategic direction, and organizational practices are all typical of the information exchanged in embedded ties (Uzzi, 1997). Because the information conveyed through ties that are more highly embedded is situation-specific and 'holistic,' in the sense that it consists of a composite of related details, it is both meaningful and instructive. The information shared is also more detailed because it pertains to the common problem that exchange partners jointly face. Managers are able to relate the information exchanged to their own operations and envision how it may assist them in solving a particular problem. Moreover, since the parties to more highly embedded ties are oriented toward sustaining the relationship, they have an interest in seeing their exchange partner succeed. Consequently, the parties actively provide each other with information about potential problems and opportunities that they anticipate (e.g., market or technological trends). This information about potential problems and opportunities assists firms in narrowing the range of options to which they can pay attention. As exchange partners share alternative practices and techniques for solving the problems that arise, it enhances their awareness of the need for new capabilities that an organization might adopt. Accordingly, we predict that information sharing influences capability acquisition by facilitating joint problem solving activities among exchange partners.

*Hypothesis 3: The relationship between information sharing with lead **suppliers** and acquisition of competitive capabilities is mediated by joint problem solving such that information sharing is positively related to joint problem solving.*

*Hypothesis 4: The relationship between information sharing with lead **customers** and acquisition of competitive capabilities is mediated by joint problem solving such that information sharing is positively related to joint problem solving.*

Trust

Awareness by itself is not sufficient to cause a firm to take advantage of potentially attractive opportunities to upgrade its competitive capabilities. Trust

allows a firm to have confidence in the information and advice provided by an exchange partner and to believe that the recommendations made are in its own best interest (Das and Teng, 1998). For this reason, trust and information sharing are highly related (Carson *et al.*, 2003; Ring and Van de Ven, 1994). Interorganizational trust refers to a common expectation among the members of an organization that another organization '(i) makes good faith efforts to behave in accordance with any commitments both explicitly or implicit, (ii) is honest in whatever negotiations preceded such commitments, and (iii) does not take excessive advantage of another even when the opportunity is available' (Cummings and Bromiley, 1996: 303). In effect, high trust allows a firm to be confident in the veracity of the advice and recommendations of an exchange partner (Uzzi, 1997). Where trust is high, a firm expects that its exchange partner will not act in its own self-interest at the firm's expense (Macaulay, 1963; Gulati, 1995; Zaheer and Venkatraman, 1995). Trust acts as an important filtering device for assessing the quality and reliability of information received about opportunities. Firms are more likely to pay attention to, weigh more heavily, and act on information received from a trusted exchange partner (McEvily, Perrone and Zaheer, 2003).

Trust also makes it possible for a firm to be more open with its exchange partners (Dore, 1983; Ouchi, 1979). In order for lead customers and suppliers to provide information and guidance useful for solving problems and discovering new capabilities, it is necessary for the focal firm to reveal certain details about its operations and the challenges it faces. Firms may be reluctant to reveal such sensitive and proprietary information to a customer out of fear that it may be used against the firm in the future (e.g., cost or productivity data could be used to demand lower prices in the future). Firms may also not want to expose sensitive and proprietary information to suppliers out of concern that the information will be shared with rivals.

Similarly, when problems arise in an interfirm exchange relationship, trust facilitates the discovery of mutually agreeable, integrative solutions (Dore, 1983; Macneil 1980). When trust is high, exchange partners are less likely to opportunistically exploit unforeseen contingencies (John, 1984) and instead view a problem as a joint one to be solved collectively. This is consistent with the idea

that firms that trust their exchange partners are committed to preserving their interfirm relationship, as opposed to merely advancing individual self gain (Uzzi, 1997). Along these lines, trust leads exchange partners to give each other the benefit of the doubt and assume the best when problems emerge, rather than focus on assigning blame or questioning each other's motives (Dyer and Chu, 2003; Zaheer, McEvily and Perrone, 1998). Moreover, exchange partners that trust each other are willing to make extra efforts beyond the letter of a contract in order to overcome difficulties and help each other solve problems. In sum, we predict that trust influences the acquisition of capabilities by promoting joint problem solving among exchange partners.

*Hypothesis 5: The relationship between trust in lead **suppliers** and acquisition of competitive capabilities is mediated by joint problem solving such that trust and joint problem solving are positively related.*

*Hypothesis 6: The relationship between trust in lead **customers** and acquisition of competitive capabilities is mediated by joint problem solving such that trust and joint problem solving are positively related.*

Content of embedded ties

We are also interested in the relative influence of embedded ties with lead customers vs. lead suppliers on the acquisition of capabilities. Drawing on case studies completed at the outset of this research, we suggest that there are important differences in the content of embedded ties with lead suppliers and customers that influence the type of knowledge exchanged and the ease of implementing the practices and techniques underlying a capability. Content refers to the material (information, resources) and immaterial (social identity, authority) substance that is conveyed through a tie (Burt, 1997; Podolny and Baron, 1997). Content also implies the specification of 'behavioral processes underlying a connection between two actors' (Gulati and Westphal, 1999: 473). The case studies reveal that the content of embedded ties differs in terms of the degree of firm-specific knowledge held by lead customers vs. lead suppliers, which holds important implications for the acquisition of capabilities.

The case studies are based on extensive field interviews with executives of four job shop manufacturers in the electroplating industry, their customers and suppliers, industry consultants, and supporting regional institutions.² In each of the four case studies, we observed job shop manufacturers with highly embedded ties to both their lead customers and their lead suppliers. Relationships with customers tended to be long term, highly stable (with some relationships lasting up to 35 years), and few in number (e.g., 10 customers accounting for 70% of sales). Relationships with suppliers were also long term (e.g., 10–35 years) and few in number, with the bulk of purchases (e.g., 70–80%) coming from one or two suppliers. Despite the similarities between job shops' embedded ties with their lead customers and their lead suppliers, we also noted important differences in relationships with these two kinds of exchange partners. Most importantly, the case studies revealed that while both customers and suppliers convey knowledge pertinent to job shops' capabilities, the type of knowledge conveyed and how it influences job shops' capabilities differed.

Joint problem solving between job shops and their lead customers was predominantly focused on evaluating, controlling, and improving the quality levels of the metal coatings applied to customers' parts. The desire to achieve and maintain high levels of quality influenced the type of exchange relationship lead customers had with job shops. The exchange relationships became more deeply embedded, as the following remarks indicate:

Because of the process and the sensitivity of it, we don't move around much and as long as I've worked here (25 years), [they are] the only one that has plated these . . . We have a very small supplier base, which allows you to have a very close working relationship. And I go back and forth to our suppliers and they're here. You get to know them on a, even a personal basis because you become almost one . . . We've worked with them so

long they can probably tell us what we need before we know what we need . . . They know us, what our requirements are. We work more efficiently together. For me it's a real trust type of thing. They get to know you and it's just like your family, you go to bat for your family.

Such exchange ties provide a context conducive to joint problem solving on issues of common interest such as quality. In the exchange relationships we observed, the approach taken to improving quality centered on identifying variations in key properties of metal coatings, which can be readily measured using objective indicators. Drawing on their analysis of the quality of the coatings applied, customers provide job shops with feedback about the frequency and type of variation observed. This is based on measurable and precise indicators of a job shop's output. Such output-based knowledge allows job shops and their customers to narrow the range of potential causes of variation, be they in the job shop's process, the way the customer has manufactured a particular part, or some combination of the two. The CEO of one customer firm we interviewed provided the following description of how they work with job shops to address quality problems:

There's such an interaction between what we supply to a plater. What kinds of oils do we use, are our parts clean? Our surface—what cutting tools were used, they may have added something to the surface of the metal. All these kinds of things are factors. When there is a problem, I can call and say hey, we've got a problem, come on over here and look at things. Maybe we screwed up on something.

Drawing on customers' output-based knowledge, the parties work together to pinpoint the sources of the problem and, when appropriate, customers suggest specific quality practices for the job shop to consider in order to improve quality. However, customers rarely provide hands-on technical assistance to help job shops integrate new techniques into their operations.

Joint problem solving with suppliers is somewhat different, due in part to differences in the ability to verify the quality and performance of a supplier's product, which in turn affects the type of knowledge exchanged. In many ways, suppliers are the most important and closest technical advisors that job shops have. Job shops frequently rely on suppliers for technical advice when troubleshooting or developing new ways of doing

² A total of 20 interviews were completed with 16 individuals from 13 different organizations. All interviews were completed on-site using a semi-structured interview format and included plant tours. Interviews varied from 1 to 4 hours and all interviews were tape-recorded (approximately 30 hours) and transcribed (roughly 300 pages). In addition to interview transcripts, the case studies are based on field notes taken during interviews and plant tours that capture our direct observations of organizing practices and principles. Company records, reports, and correspondence constitute a third source of data for the case studies. Complete details of the case studies are available from the authors upon request.

things. Because suppliers are so knowledgeable, job shops are willing to entrust critical processes in the hands of these experts. Job shops are also very loyal to their suppliers for the same reason. In the words of one job shop President, 'this is a technical industry, a supplier's knowledge and credibility are very important. I know that my current suppliers won't lead me astray.'

Joint problem solving with suppliers was best exemplified in one of the job shops we studied that was working on a pollution prevention project to replace cyanide with a more benign chemical process. In order to facilitate the transition to the alternative process, the job shop constructed a completely new manufacturing line and had technicians from the supplier working with it on-site over a period of a couple of weeks. Initially, the two struggled to get the new chemical process to work to the job shop's satisfaction. Whereas the performance of the cyanide process was very consistent, the new chemical process was highly sensitive to variations in operating conditions (e.g., time, temperature, concentration, pH level) that interacted in ways that were not well understood. After repeated trial-and-error experimentation, adjustment, analysis, and checking, the new process finally achieved acceptable performance on a consistent basis. As the job shop CEO described:

They had a couple of tech people in here most of the time, you know holding our hand and actually working with us hands on to start with. All day for a few days, every day. I mean they were here while we were plating and they were constantly analyzing and adjusting, constantly checking everything that was happening. And as we got a little more comfortable, they spent less and less time [here].

Since the operating conditions, equipment, level of expertise, and applications differ from one job shop to the next, the way that a supplier's product performs in a given setting varies as well. One supplier representative we spoke with described the challenge of servicing his product to different job shops in the following way, 'You may end up with a totally divergent process, in most cases you do because no two shops are alike.' As a result, assessing quality and performance in exchange relations with lead suppliers is idiosyncratic and not readily verified with objective measures, which is an important difference from exchange relations with lead customers.

This underscores a key distinction between the content of ties with lead customers and lead suppliers, both in terms of the type of knowledge exchanged and the way they work with job shops to solve problems. Since the quality and performance of the product exchanged with suppliers is less easily verified than is the case with customers, the type of knowledge exchanged with suppliers centers on implementation of practices and techniques. Having the ability to observe suppliers demonstrate new processes in a 'hands-on' setting is a highly effective way to solve problems and convey knowledge that is technically complex and difficult to articulate. Although lead customers also exchange knowledge with job shops in the course of solving problems, the knowledge is output-based due to the relative ease of verifying product quality and performance. Consequently, the knowledge exchanged with lead customers during joint problem solving influences job shops' acquisition of capabilities by raising awareness of, and affecting the intention to acquire, practices and techniques. Knowledge exchanged with lead suppliers goes one step further by also facilitating the implementation of practices and techniques. Because of this difference in the content of ties, we expect that embedded ties with lead suppliers will exert a greater influence on the acquisition of capabilities than embedded ties with lead customers. This leads to our final hypothesis:

Hypothesis 7: Joint problem solving with lead suppliers will be more strongly related to acquisition of competitive capabilities than joint problem solving with lead customers.

RESEARCH METHODS

To test our predictions we identified a population of firms—job shop manufacturers—that differ in their degree of embeddedness with lead customers and suppliers and that vary in their propensity to acquire competitive capabilities. An advantage of the field setting is that the job shop manufacturers that we study are similar in size, rely on similar production technologies, and compete in similar markets. Moreover, since job shop manufacturers tend to be regionally based, we can control for geographical differences.

Research design and data collection

The sampling frame consisted of all job shop manufacturers operating in seven industries in two Midwestern states: electroplating (SIC 3471), coating and painting (SIC 3479), printed circuit board manufacturing (SIC 3672), screw machining (SIC 3451), stamping (SIC 3469), sheet metal fabrications (SIC 3444), and machining (SIC 3599). We selected these industries because they were similar in terms of their composition (e.g., number of firms, average age of firms, customer base).

For the purpose of our research we constructed a primary dataset using a mailed questionnaire. Officials from a regional institution located in both states—the Manufacturing Extension Partnership (MEP)³—compiled and made available a list of all firms operating in the job shop industries under study. These lists were *not* limited to only those firms that had participated in MEP programs, but also identified job shop manufacturers in the states that had not participated. These lists were also more comprehensive and accurate when compared to directories available from commercial (e.g., Dun and Bradstreet) or other governmental (e.g., state directories of manufacturing firms) sources.

A preliminary version of the survey instrument was pretested among a group of 22 executives of local job shop manufacturing companies from an industry not among those identified above. Feedback from these executives was incorporated into a revised version of the survey instrument, along with comments and suggestions from industry experts, officials from the MEPs, and several colleagues knowledgeable in survey design.

The final questionnaire was mailed to a random sample of 1000 chief executive officers or presidents of job shops. We directed the survey to CEOs/Presidents because our preliminary field interviews indicated that these individuals were best able to respond to questions about organizational and strategic issues relating to their respective firms. This approach is consistent with the selection of key informants knowledgeable about organizational matters by virtue of their position (John and Weitz, 1988). We also implemented Dilman's (1978) techniques for maximizing response

rate. In addition to the initial survey mailing, extensive follow-up communications were carried out including: (1) sending a reminder/thank you postcard, (2) sending a second round of mailings to nonrespondents, and (3) placing a telephone call to any remaining nonrespondents.

A total of 309 executives responded to the request for information about their company. This number is approximately 31 percent of the original 1000 firms surveyed. The follow-up telephone calls revealed that 178 of the original 1000 firms were not eligible to participate in the study, and we eliminated these firms from our initial sampling frame.⁴ The actual response rate then equaled 38 percent (i.e. 309/822) of eligible firms. Complete responses were obtained from 234 of these firms. All of the firms from which we obtained responses had 500 or fewer employees. Further, 75 percent of the firms had 63 or fewer employees. On average, firms in our sample had sales of \$2 million and had been in operation for 30 years. Over 95 percent of the firms in the sample were privately owned.

Testing for nonresponse bias

The overall response rate of 38 percent, while reasonable, raises the possibility that the sample of responding firms systematically differed from the remainder of the population. We addressed the potential for nonresponse bias by comparing certain key attributes of respondents (firm size in terms of the total number of employees and annual sales) to those of a group of 50 randomly selected nonrespondents. We obtained size and sales data for the 50 nonrespondents from one of the MEPs. *t*-tests revealed no significant differences between the mean size ($t = -1.29$) and the mean sales ($t = -1.83$) of respondents and nonrespondents, although the near significance of the difference in the mean sales suggests the possibility of some bias in our sample toward firms with higher sales. To further confirm the representativeness of our sample, we conducted a Kolmogorov–Smirnov two-sample test. For the variables of both size and sales we found no significant differences between our sample and the random sample of 50 nonrespondents. *p*-values were, respectively, 0.225 and

³ The Manufacturing Extension Partnership (MEP) is a national system of extension centers operated by the National Institute of Standards and Technology. The charter of the regionally based MEPs is to promote the deployment of new manufacturing technology, production techniques, and business practices among small manufacturers.

⁴ Firms deemed ineligible to participate in our study include those that were not job shop manufacturers, had gone out of business, or had zero employees.

0.357, suggesting that the two samples were drawn from the same population. While not definitive, these tests provided some assurance that the sample of firms responding to the questionnaire was closely representative of the broader population surveyed (Siegel, 1956).

Operational measures

Table 1 presents the details of the measurement instruments and scales used to operationalize our theoretical constructs. The Cronbach α reliabilities for each construct are also reported in Table 1. With the exception of the quality management construct, which is marginal at 0.61, constructs were at or above the value of 0.70 (Nunnally, 1978). Descriptive statistics and zero-order correlations among constructs are reported in Table 2.

Acquisition of competitive capabilities

Consistent with Meyer and Goes (1988) we view competitive capabilities as being acquired through a multistage, organizational process. To develop a variable for statistical analysis, we created a 7-point scale that captures three primary stages associated with the acquisition of capabilities: knowledge–awareness, evaluation–choice, and adoption–implementation.

We evaluated two competitive capabilities using the acquisition scale: pollution prevention and quality management. Following Amit and Schoemaker (1993), we focused on industry-specific competitive capabilities that were identified during the initial phase of field research. A careful analysis of the field interviews and subsequent confirmation by industry experts strongly suggested that central to sustaining competitive advantage in this industry were: (1) effective management of hazardous materials via pollution prevention, and (2) minimization of variations in production processes via quality management. Acquisition of capabilities in these areas was critical because the industry faced key challenges from environmental risks and regulation, heightened competition and a rapidly changing market, and innovations in processing chemistry and equipment.

Pollution prevention. Pollution prevention capabilities have become salient with the passage of laws and treaties governing the use, emission, and reporting of hazardous materials integral to the

production process of the industries we examined.⁵ According to the U.S. Environmental Protection Agency (1990), pollution prevention emphasizes the judicious use of resources through source reduction, energy efficiency, reuse of scrap materials during production, and reduced releases of hazardous or toxic materials. We operationalized pollution prevention with three items measuring various product and process changes. These items were adapted from a national survey of pollution prevention conducted in one of the job shop industries selected for this study (Cushnie, 1994).

Quality management. Although total quality management (TQM) means different things to different people, the elimination of production defects through continuous improvement of processes is a common feature of most definitions (Hackman and Wageman, 1995). A core principle guiding the management of quality improvement is the analysis of variability in processes and outcomes through systematic data collection and statistical analysis (Deming, 1986; Juran, 1974). In this study, TQM was measured with three items capturing the use of statistical process control charts to provide operators with feedback. These items are based on the measurement instrument developed by Flynn, Sakakibara, and Schroeder (1995).

Embedded ties

We developed parallel instruments to measure the extent to which a firm has embedded ties with its lead customer and lead supplier in terms of joint problem solving, information sharing, and trust. Our *joint problem-solving* construct was measured using a three-item instrument based on the scale developed and validated by Heide and Miner (1992). The instrument captures the degree to which exchange partners share the responsibility for resolving problems as they arise. *Information sharing* captures the degree to which parties actively exchange information beyond the letter of the contract—information that can facilitate the other party's activities. We used a modified

⁵ Some of the most relevant examples include amendments to environmental regulations, such as the Superfund Amendments and Reauthorization Act of 1986 (SARA), the Clean Water Act Amendments of 1987, the Global Climate Protection Act of 1987, the Clean Air Act Amendments of 1990, and the Pollution Prevention Act of 1990. The Montreal Protocol signed in 1990 put additional pressure on firms to eliminate or reduce solvent use.

Table 1. Measurement instruments

Measurement items	Scales	Internal consistency reliability (α)
<i>Pollution prevention capabilities</i>		
1. Substitute less hazardous raw materials for more hazardous ones	1 = We know little about this practice 2 = We know about this practice, but do <i>not</i> do it 3 = We have considered doing this 4 = We decided <i>not</i> to do this after considering it 5 = We do this from time to time 6 = We do this most of the time 7 = We do this all of the time	0.72
2. Offer new products/services because of low waste disposal costs		
3. Discontinue products/services high in environmental management costs		
<i>Quality management capabilities</i>		
1. Collect data on your company's production process variations	1 = Strongly disagree 2 = Disagree 3 = Slightly disagree 4 = Neutral 5 = Slightly agree 6 = Agree 7 = Strongly agree	0.61
2. Provide charts and graphs to production employees reporting defect rates		
3. Conduct experiments to isolate causes of defects		
<i>Joint problem solving</i>		
1. Our main [customer/supplier] works with us to overcome difficulties	Customer 0.79 Supplier 0.83	
2. We are jointly responsible with our main [customer/supplier] for getting things done		
3. We work with our main [customer/supplier] to help solve each other's problems		
<i>Information sharing</i>		
1. Our main [customer/supplier] warns us of events that may create problems for us	Customer 0.77 Supplier 0.72	
2. Our main [customer/supplier] shares its plans for the future with us		
3. Our main [customer/supplier] shares proprietary and sensitive information with us		
<i>Interorganizational trust</i>		
1. Our main [customer/supplier] negotiates fairly with us	Customer 0.87 Supplier 0.86	
2. Our main [customer/supplier] does not mislead us		
3. Our main [customer/supplier] keeps its word		
<i>Vicarious learning</i>		
To what extent does your company:	1 = To no extent 4 = To some extent 7 = To a great extent	0.82
1. Look at different approaches used by other companies?		
2. Get ideas about new ways of working from other companies?		
3. Improve the way you work by observing what other companies do?		
<i>Participation in regional institutions</i>		
1. Obtain on-site assistance at your company from [name of extension center]	1 = We know little about this service 2 = We know about this service, but do <i>not</i> do it 3 = We considered doing this 4 = We decided <i>not</i> to do this after considering it 5 = We did this once 6 = We did this a couple of times 7 = We did this several times	0.75
2. Select/install new equipment or computer systems with [name of extension center]		
3. Participate in user groups or networks organized by [name of extension center]		

(continued overleaf)

Table 1. (Continued)

Measurement items	Scales	Internal consistency reliability (α)
<i>Network structure (non-redundancy)</i>		
1a. Please write the initials of the five most important people <i>not employed by your company</i> that you rely on for advice about managing your business	(not applicable)	(not applicable)
1b. Now, using the table provided indicate if these people know each other. If so, circle 'Y' for yes		
<i>Firm size^a</i>		
1. Roughly how many <i>full-time equivalent</i> employees worked for you in fiscal year 1995?	(not applicable)	(not applicable)
2. Roughly how many <i>temporary and seasonal</i> employees worked for you in fiscal year 1995?		

^a Firm size = sum of items 1 and 2 (standardized z-score).

Table 2. Descriptive statistics and zero-order correlations among constructs

	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11
<i>Competitive capabilities</i>													
1. Pollution prevention	3.83	1.78											
2. Quality management	4.51	1.50	0.30**										
<i>Embedded ties (supplier)</i>													
3. Problem solving	5.34	1.45	0.21**	0.23**									
4. Information sharing	4.02	1.33	0.28**	0.13*	0.40**								
5. Trust	5.72	0.97	0.09	0.07	0.35**	0.41**							
<i>Embedded ties (customer)</i>													
6. Problem solving	6.50	0.77	0.09	0.12*	0.29**	0.10	0.02						
7. Information sharing	5.01	1.32	0.08	0.14*	0.33**	0.28**	0.15**	0.20**					
8. Trust	5.89	1.03	0.01	0.05	0.25**	0.14*	0.20**	0.16**	0.57**				
<i>Controls</i>													
9. Vicarious learning	4.55	1.47	0.25**	0.29**	0.11	0.15*	0.01	0.03	0.18**	0.05			
10. Regional participation	2.13	1.40	0.13*	0.22**	0.08	0.00	-0.01	-0.00	0.13*	0.05	0.21**		
11. Network structure	0.99	0.63	0.13*	0.03	0.03	-0.02	-0.04	-0.01	0.03	0.04	0.03	-0.12*	
12. Firm size	0.00	1.00	-0.02	0.26**	0.08	0.02	0.04	-0.10	0.01	-0.12*	0.03	0.03	-0.04

** $p < 0.01$; * $p < 0.05$

version of the instrument developed and validated by Heide and Miner (1992) for measuring information sharing. We operationalized *interorganizational trust* in a lead customer or supplier with a three-item scale reflecting the degree to which the exchange partner is fair in its dealing and does not try to take advantage of the focal firm. Interorganizational trust describes the extent to which the members of a focal firm have a collectively held trust orientation toward a customer or supplier firm (Zaheer *et al.*, 1998). Our trust measurement instrument is based on a shortened version of the scale developed and validated by (Cummings and Bromiley, 1996).

Control variables

In order to assess the unique contribution of our predictions, we control for alternative explanations for the sources of capabilities.

Learning orientation. In addition to learning from their own experiences, we have proposed that firms learn from the experience of others, particularly lead customers and suppliers. However, it may be the case that the overriding determinant of external sources of capabilities is a firm's propensity to draw on its network of interorganizational ties and that linkages to customer and supplier firms, per

se, are no more significant than other ties. Without controlling for the general inclination to learn from network contacts, linkages to customer and supplier firms may be reflecting some of the effects of firms learning from their overall networks. To rule out this possibility, we control for a firm's *vicarious learning orientation* (Levitt and March, 1988). The construct was measured using an instrument based on the measurement scale developed by Yeung and Ulrich (1994) that captures the extent to which a firm relies on the past experiences of others.

Network structure. Both Kraatz (1998) and McEvily and Zaheer (1999) found that the structure of a firm's overall network influences its acquisition of capabilities. In particular, the extent to which contacts are not directly connected (i.e., nonredundant) affects the diversity of information accessed and the likelihood of discovering new information and opportunities (Burt, 1992). To operationalize nonredundancy, this study uses an ego-centered network measure based on an instrument designed and developed specifically for use in the small firm context (Aldrich, Rosen, and Woodward, 1986). This instrument asks respondents (ego) to identify the five most important external sources of advice (alters) relied upon and to report the extent to which these five sources know each other. Using this matrix, a nonredundancy score, indicating the ratio of nonredundant ties per advisors, was computed as follows:

$$\text{Nonredundancy} = \frac{(\text{Potential Ties} - \text{Actual Ties})}{\text{Number of Advisors}}$$

where Potential Ties = the maximum number of ties that could exist among advisors (0 to 10), or $n(n-1)/2$, where n is the total number of advisors listed; Actual Ties = the number of ties that do exist among advisors (0 to 10); and Number of Advisors = the total number of advisors listed (0 to 5).

Regional associations. Following Kraatz (1998) and McEvily and Zaheer (1999) we control for *participation* in industry or regional associations that provide firms with access to a greater breadth of knowledge about competitive capabilities. This construct indicated the extent to which a firm used

the services available from a regional industrial extension center. A 7-point scale similar to the acquisition scale was developed to measure participation and capture three primary decision-making stages: knowledge–awareness, evaluation–choice, and utilization. Participation was measured with a three-item scale capturing the use of services available.

Firm size. Larger firms have greater slack resources, such as managerial and engineering expertise and time, thus making experimentation with new practices and techniques more feasible (Kelley and Brooks, 1991). Moreover, since the scale economies associated with spreading the costs of implementing capabilities over a larger base of operations are greater in larger firms, they may find it easier to acquire capabilities than smaller firms may. Consequently, the final factor for which we control is firm size, operationalized as the sum of full-time employees, and temporary and seasonal workers.

Construct validity

A measure of a construct is valid to the extent that it actually measures what it purports to measure (Carmine and Zeller, 1979). The logic of construct validity suggests that multiple indicators of the same theoretical construct should be positively and strongly related. More specifically, the convergent validity of a construct is demonstrated by showing that each indicator loads only onto its associated theoretical construct. We evaluated the convergent validity of the constructs in this study by examining the factor loadings of each operational variable (i.e., corresponding to a survey item) on its associated latent construct. Factor loadings were estimated using structural equation modeling. The results of this analysis revealed that the factor loadings on each construct were large and statistically significant ($p < 0.001$). This suggests that each indicator is strongly related to its underlying construct and is evidence supporting the convergent validity of the measures.

Discriminant validity

The degree to which two theoretical constructs differ from each other indicates discriminant validity. The discriminant validity of two constructs can

be assessed by demonstrating that the correlation between a pair of constructs is significantly different from unity. We test discriminant validity by comparing a constrained structural equation model (i.e., correlation fixed to equal 1.0) with an unconstrained model (i.e., correlation freely estimated). A significantly lower χ^2 value for the unconstrained model supports the discriminant validity criterion. Separate structural equation models were specified to test the discriminant validity of the theoretical constructs: one for the dependent variables (acquisition of capabilities) and one for the independent variables (embedded ties and control variables). Each model was first estimated with all correlations among latent variables left unconstrained and then, one at a time, the correlation between each pair of latent variables was constrained to unity and the models were re-estimated. In all cases, the χ^2 value for the unconstrained model was significantly lower ($p < 0.001$) than the χ^2 value for the constrained model indicating satisfactory discriminant validity.

Assessing common method variance

As noted earlier, the bulk of the firms in our sample are owner-operated small manufacturing firms. The CEO or President of these firms was typically the only individual knowledgeable enough to respond to the survey and secondary data for the variables of interest were not available. Consequently, the potential for common method variance may exist since a single data source was used to measure the independent and dependent variables. To investigate this possibility we implemented a variation of Harmon's single factor test using structural equation modeling. This technique assumes that 'if a substantial amount of common method variance is present . . . one "general" factor will account for the majority of covariance in the independent and criterion variables' (Podsakoff and Organ, 1986: 536). We tested for common method variance by comparing a model loading all of the observed variables onto a single latent variable with a measurement model that loaded observed variables onto theoretically assigned latent variables. The χ^2 value for the measurement model was significantly lower than the χ^2 value for the single factor model (difference in $\chi^2 = 906.81$, 2 d.f., $p < 0.001$), indicating a superior fit to the data. We also evaluated the

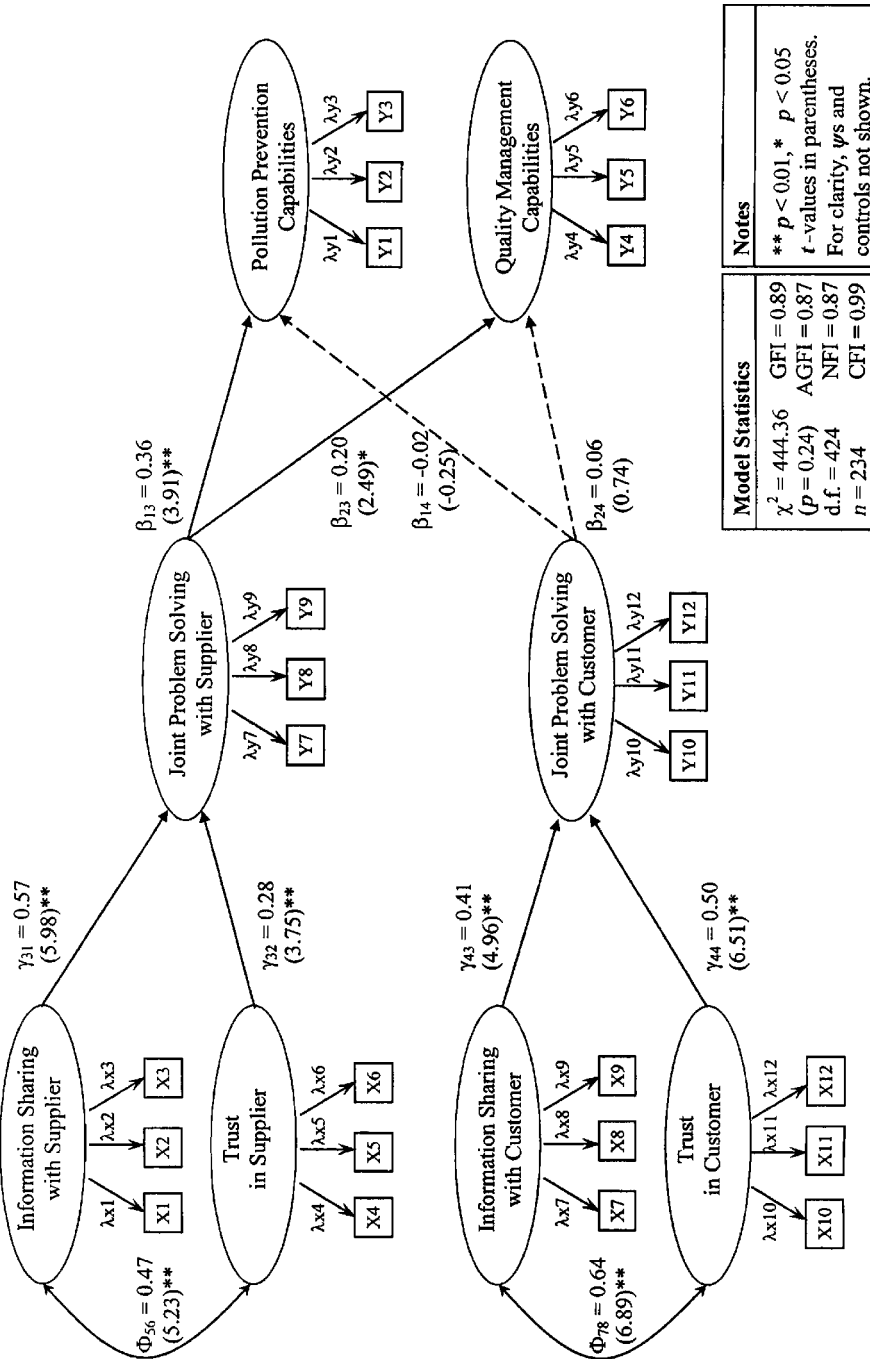
potential for common method variance by performing a principal components factor analysis on all of the items. The factor analysis extracted 10 factors, with the first factor accounting for 21 percent of the total variance. While by no means definitive tests, these results provide some indication that the observed relationships among constructs are not largely accounted for by systematic variance associated with the measurement technique.

ANALYSIS AND RESULTS

To test the hypotheses developed earlier we specified a structural equation model using LISREL 8 (Jöreskog and Sörbom, 1996). We used the maximum likelihood procedure to estimate the model. We chose to analyze our data using structural equation modeling because it offers the advantage of specifically modeling measurement error associated with indicators, rather than assuming that constructs are measured without error. More importantly, structural equation modeling provides the capability of simultaneously estimating a system of structural equations, which is important for testing the mediation model proposed. Specifically, our theoretical model predicts that information sharing and trust influence the acquisition of capabilities through their effect on joint problem solving, which is hypothesized to be directly related to capabilities acquisition (see Figure 2). Although not shown, the model also includes controls for firms' learning orientations, network structures, participation in regional associations, and size.⁶

The structural equation model estimated a series of path coefficients reflecting the relationships specified among the latent variables. The beta coefficient (β) indicates the structural path among dependent (endogenous) latent variables, which in this case is the link between joint problem solving and acquisition of competitive capabilities. The gamma coefficient (γ) represents the structural paths between the independent (exogenous) latent variables and the dependent (endogenous) latent variables. The association between trust and joint problem solving is an example of a gamma path coefficient. The phi coefficient (ϕ) represents

⁶ In separate analyses we have investigated the possibility of industry effects on the results of this model. The inclusion of industry controls does not alter the sign or level of statistical significance of any predictor variables in the structural equation model.



Model Statistics		Notes
$\chi^2 = 444.36$	GFI = 0.89	** $p < 0.01$, * $p < 0.05$
($p = 0.24$)	AGFI = 0.87	t-values in parentheses.
d.f. = 424	NFI = 0.87	For clarity, γ s and
n = 234	CFI = 0.99	controls not shown.

Figure 2. Embedded ties: structural equation model

the association among exogenous variables (e.g., information sharing and trust). The sign and statistical significance of the beta and gamma path coefficients serve as a test of the hypothesized relationships.

The results for the structural equation model include the path coefficients and *t*-values (shown in parentheses) corresponding to each hypothesized relationship, and a series of standard fit indices⁷ reflecting the degree of overall fit between the actual and predicted covariances among variables in the model. The χ^2 statistic tests the correspondence between the model and the underlying data.

The estimated structural equation model demonstrated a χ^2 (424 d.f.)⁸ value of 444.36 ($p = 0.24$). All fit indices are 0.87 or above, indicating a reasonable fit of the model with the data (see Figure 2).

Hypothesis 1. The model provided strong support for the hypothesis predicting a positive relationship between joint problem solving with suppliers and acquisition of competitive capabilities. As predicted, the joint problem solving with suppliers to pollution prevention link is both positive and statistically significant ($\beta_{13} = 0.36$, $t = 3.91$, $p < 0.001$). Similarly, the relationship between joint problem solving with suppliers and quality management capabilities is positive and statistically significant ($\beta_{23} = 0.20$, $t = 2.49$, $p < 0.05$).

Hypothesis 2. The prediction that joint problem solving with customers and acquisition of competitive capabilities would be positively related is *not supported*. Neither the relationship between joint problem solving with customers and pollution prevention ($\beta_{14} = -0.02$, $t = -0.25$, n.s.) nor the link to quality management capabilities is statistically significant ($\beta_{24} = 0.06$, $t = 0.74$, n.s.).

Hypothesis 3. The hypothesis predicting a positive relationship between information sharing and joint problem solving with lead suppliers is *supported*. The relationship is positive and statistically significant ($\gamma_{31} = 0.57$, $t = 5.98$, $p < 0.001$).

Hypothesis 4. Similarly, the hypothesized relationship between information sharing and joint problem solving with lead customers is *supported*. As predicted, the relationship is positive and statistically significant ($\gamma_{43} = 0.41$, $t = 4.96$, $p < 0.001$).

Hypothesis 5. The predicted positive relationship between trust and joint problem solving with suppliers is also *supported* by the data. The link between the two variables was not only positive, but also statistically significant ($\gamma_{32} = 0.28$, $t = 3.75$, $p < 0.001$).

Hypothesis 6. Additionally, the hypothesis relating trust to joint problems solving with customers is *supported*. As predicted, the relationship is positive and statistically significant ($\gamma_{44} = 0.50$, $t = 6.51$, $p < 0.001$).

Hypothesis 7. The final prediction that joint problem solving with suppliers would more strongly influence the acquisition of capabilities than joint problem solving with customers is also borne out by the data. As the model indicates, joint problem solving with suppliers shows a positive effect on the acquisition of both capabilities, while joint problem solving with customers is unrelated to the two capabilities.

Although not hypothesized, the structural equation model also estimates the relationship between information sharing and trust. As can be seen in Figure 2, the relationship is positive and statistically significant for both customer ($\phi_{78} = 0.64$, $t = 6.89$, $p < 0.001$) and supplier relations ($\phi_{56} = 0.47$, $t = 5.36$, $p < 0.001$).

Control variables

The control variables (not shown in the model) are also significantly related to the acquisition of capabilities. Participation in regional institutions shows a positive and statistically significant relationship to both pollution prevention ($\beta_{15} = 0.17$, $t = 1.93$, $p < 0.055$) and quality management capabilities ($\beta_{25} = 0.21$, $t = 2.52$, $p < 0.05$), as does vicarious learning ($\gamma_{15} = 0.18$, $t = 2.34$, $p < 0.05$ for pollution prevention and $\gamma_{25} = 0.27$, $t = 3.54$, $p < 0.001$ for quality management). Network structure is positively and statistically significantly related to pollution prevention capabilities ($\gamma_{16} = 0.24$, $t =$

⁷ Four fit indices are reported for each of the models estimated. The goodness of fit index (GFI) indicates the relative amount of variance and covariance jointly explained by the model. The adjusted goodness of fit index (AGFI) is similar to GFI, but adjusts for the number of degrees of freedom in the model. The normed fit index (NFI) (Bentler and Bonett, 1980) represents the point at which the model being evaluated falls on a scale from a null model (specifying mutual independence among indicators) to a perfect fit. The comparative fit index (CFI) (Bentler, 1990) is the same as the NFI, but corrects for small sample size by subtracting the degrees of freedom from their corresponding chi-square values. Each index ranges from zero to 1.00, with values closer to 1.00 indicating a good fit. A commonly accepted rule of thumb is that a fit index should be greater than 0.90.

⁸ Using the guidelines developed by MacCallum, Browne, and Sugawara (1996) we can conclude that the model achieves adequate statistical power given the degrees of freedom and number of observations.

2.23, $p < 0.05$), while the link between firm size and quality management capabilities is positive and statistically significant ($\gamma_{27} = 0.41$, $t = 5.23$, $p < 0.001$).

Robustness of the results

The structural equation model estimated appears to provide strong support for the hypothesized relationships linking embedded ties with suppliers to capability acquisition. However, the model was less supportive of the relationship between embedded ties with customers and the acquisition of capabilities. To explore the stability of the results, we performed additional analyses that might reveal alternative formulations of the relationship between embedded ties with customers and the acquisition of capabilities. In particular, we examined whether each attribute of embedded ties with customers is directly related to acquisition of capabilities, rather than information sharing and trust being mediated by joint problem solving. To test this possibility we added direct paths from customer information sharing and trust to both capabilities. The revised model's fit is not significantly better and none of the added paths are statistically significant. As a further test of the possible direct effects of customer information sharing and trust on acquisition of capabilities, we estimated a third model that removed the paths linking information sharing and trust to joint problem solving with customers. Whereas the second model estimated direct and indirect paths, the third model only includes direct paths. The third model's fit is substantially worse than the first model's and once again none of the direct paths from information sharing and trust to capabilities are statistically significant. Taken together, the overall pattern of results offers consistent evidence that fails to support the relationship between embedded ties with customers and the acquisition of capabilities.

We also repeated these analyses for the embedded ties with suppliers variables. Once again, neither the added direct path from information sharing with suppliers nor the direct path from trust in suppliers reveal a statistically significant relationship with either pollution prevention or quality management capabilities. We then removed the paths from information sharing and trust to joint problem solving with suppliers to test for their direct effects on capability acquisition alone. The paths from trust in suppliers to capabilities remain

non-significant, but one of the two information-sharing paths (to pollution prevention capabilities) is positive and statistically significant ($\gamma_{13} = 0.25$, $t = 2.42$, $p < 0.05$). However, the fit of this model is significantly worse than the initial model (the difference in $\chi^2 = 115.57$, with 2 d.f., and is significant at $p < 0.001$). This suggests that the initial model, with joint problem solving as a mediator, provides the best fit to the data.

As a final check of the robustness of the proposed model, we investigated alternative specifications of the latent constructs to determine whether a different configuration of variables provided a superior fit to the data. We estimated a series of models that explored various combinations of variables (e.g., combining information sharing and trust, combining customer and supplier variables). In all cases, the fit of the alternative models was substantially worse than the proposed model. An examination of the modification indices provided by LISREL further confirmed that there are no substantial sources of variation that the proposed model has omitted. Based on these findings, we are reasonably confident that the proposed model provides the best fit of the data.

Discussion

The findings from this research broaden and deepen our understanding of how firms acquire competitive capabilities and underscore the need to reconsider existing assumptions regarding the sources of capabilities. Whereas most extant work on the origins of capabilities has looked within the firm, we extend recent strategy research that views capabilities as externally embedded in a firm's network of interorganizational relationships (Ahuja, 2000; Gulati, 1999; McEvily and Zaheer, 1999; Stuart, 1998). The evidence reported here is consistent with the notion that interfirm exchange relationships represent an important external learning opportunity for discovering, evaluating, and implementing competitive capabilities. In addition to engaging in their own trial-and-error experimentation to develop capabilities, firms learn about capabilities vicariously through embedded ties with critical exchange partners. But, perhaps the more important contribution of this research is to provide insight into the underlying mechanisms that facilitate the acquisition of capabilities through interfirm ties.

Previous network research on the acquisition of capabilities has identified information sharing and trust as key mechanisms promoting capability acquisition. The results reported here confirm that these mechanisms are in fact instrumental to the acquisition of capabilities through interfirm ties, but further indicate that they play a more subsidiary role than previously thought. In this study joint problem-solving arrangements is the more prominent driver of capability acquisition and acts as a critical linking mechanism between embedded ties and the acquisition of capabilities. Joint problem solving provides a forum for managers to improve their comprehension of the tacit knowledge underlying capabilities and their understanding of how to customize a capability to the unique circumstances of their firm. Through experimentation, observation, and demonstration, firms are able to draw on the insights, experiences, and abilities that lead suppliers have with a capability. Information sharing and trust, on the other hand, exert indirect effects on the acquisition of capabilities by creating a foundation upon which joint problem solving can occur. Viewed this way, information sharing and trust act as precursors to the more immediate effects of joint problem solving on capability acquisition.

The observation that trust enables other critical processes is particularly noteworthy. Recent research on work group performance has observed a similar finding. Rather than having a direct effect on performance, trust influences how motivation is translated into group processes and performance (Dirks, 1999; Dirks and Ferrin, 2001). More generally, the accumulating evidence that trust acts as a facilitator of a variety of organizational outcomes is consistent with the notion that 'Trust is an important social lubricant of a social system' (Arrow, 1974: 23).

Another contribution of this research is to reveal the heterogeneous influence of different types of embedded ties on the acquisition of capabilities. The results of our empirical analysis and case studies clearly indicate that embedded ties with lead suppliers exhibited a greater influence on the acquisition of capabilities than did embedded ties with lead customers. The difference between the effect of embedded ties with lead suppliers vs. lead customers and acquisition of capabilities is most evident in the extent of joint problem solving that occurs in each type of relationship. With customers, joint problem solving is

practiced at a high level almost uniformly by all firms and there is little variation (mean is 6.50 and S.D. is 0.77). Consequently, there is little opportunity for achieving competitive advantage through the acquisition of capabilities. Conversely, joint problem solving with suppliers is practiced to a lesser degree (mean = 5.34) and varies to a greater extent (S.D. = 1.45), and therefore is more consequential for achieving competitive advantage through the acquisition of capabilities. The fact that more firms engage in joint problem solving with customers makes it less valuable from the perspective of achieving competitive advantage from the acquisition of capabilities.

The observation that lead suppliers were instrumental in facilitating the implementation of the practices and techniques underlying a capability for competitive advantage suggests that in order to influence capability acquisition embedded ties must go beyond raising awareness of opportunities to enhance performance. Embedded ties must also reduce the uncertainty associated with implementing a new capability. This finding highlights the importance of the content of ties for the acquisition of capabilities. The relative ease with which lead customers could verify the quality and performance of goods exchanged limited their knowledge of the firm's operations. For this reason, knowledge exchanged in embedded ties with lead customers was output-based. Conversely, the quality and performance of goods exchanged with lead suppliers was difficult to verify, requiring lead suppliers to possess a greater degree of firm specific knowledge. Knowledge exchanged with lead suppliers tended to be more implementation-based. More generally, this set of findings indicates that content, in terms of type of knowledge exchanged, varies across embedded ties and these differences help explain the relative influence of interfirm ties on capability acquisition.

Taken together, the findings from this study make important contributions to research on the sources of capabilities. Whereas previous studies have shown how a firm's acquisition of capabilities is influenced by its position in a network, or *structural* embeddedness, this paper illustrates the importance of *relational* embeddedness (Granovetter, 1992; Gulati, 1998; Rowley, Behrens, and Krackhardt, 2000), or the cohesiveness of ties and their underlying attributes. Such an emphasis on the attributes of embedded ties is important because it provides fine-grained insights into

the causal mechanisms that explain how and why embedded ties influence firms' abilities to acquire competitive capabilities.

More generally, this study holds important implications for strategy research on the sources of sustained competitive advantage (Amit and Schoemaker, 1993; Barney, 1986). Our findings challenge the assertion that differences across firms in competitive capabilities are solely a function of internal learning and resource endowments (Chandler, 1992; Helfat, 2000; McGrath *et al.*, 1995). Network resources in the form of embedded ties with exchange partners represent another important source of variation in competitiveness. Because embedded ties tend to be idiosyncratic and penetrate irregularly and in different degrees (Granovetter, 1985), they represent an important source of firm heterogeneity. Moreover, to the extent that embedded ties are based on relations of trust that evolve over time through repeated interaction, they can also be considered a relatively immobile resource that is difficult to acquire quickly. For these reasons, embedded ties may represent a network resource that is somewhat inimitable and, therefore, a sustainable source of competitive advantage. At the same time, the effects of embedded ties on firm competitiveness do not appear to be uniformly positive. Our research points to the heterogeneity across embedded ties with different types of exchange partners. While some embedded ties may be beneficial for sustaining competitiveness, others may be inconsequential or perhaps even detrimental. Therefore, the ability to discriminate the relative value of different types of embedded ties is also important.

Limitations and directions for future research

Certain features of this research influence how the results should be interpreted. Due to the cross-sectional research design employed, we were cautious about drawing conclusions about the causal direction of the relationships among key constructs. For instance, it is possible that the acquisition of capabilities preceded and influenced the establishment of embedded ties with exchange partners. However, we investigated this possibility by comparing the emergence of the capabilities we studied in the seven industries we focused on to the duration of relationships with lead customers and suppliers. We observed that, on average, ties

to customers and suppliers preceded the emergence of the capabilities by 8 years.⁹

We also considered an alternative explanation for the effects of exchange ties with customers on capability acquisition. Specifically, firms particularly dependent on customers for business might be coerced into adopting such practices and techniques. Accordingly, acquisition of capabilities should increase with dependence (Pfeffer and Salancik, 1978) on a lead customer. In fact, we checked for this possibility in our data and found the opposite—that the acquisition of capabilities decreased as dependence on customers increased.¹⁰ Capability acquisition was lower when a firm was highly dependent on its lead customer for sales. Dependence on a lead customer also coincided with a higher level of embeddedness.¹¹ Together, these results might indicate the downside of 'overembedded' ties. The convergence of dependence and higher levels of embeddedness suggests exchange relationships where the parties have exclusive arrangements to deal primarily with each other (e.g., sole-sourcing). Under such circumstances where a firm becomes a 'captive' supplier to its lead customer the drive to innovate and

⁹ More specifically, we compared the average duration of relationships with lead customers and suppliers to when the competitive capabilities we studied arrived in the seven industries identified. Although it is difficult to pinpoint the exact date when the capabilities we studied first arrived, our field interviews confirmed that it was not until after the passage and the implementation of the 1990 Pollution Prevention Act that pollution prevention practices began to emerge. We found that 84 percent of the time the relationship between a firm in our study and its lead customer was in place prior to 1990 and that 80 percent of the relationships with lead suppliers were established prior to 1990. On average, relationships with lead customers or suppliers were established 8 years prior to the passage of the amendments to federal legislation in 1990. Our field interviews further confirmed that the emergence of quality management practices coincided with the rise of pollution prevention practices in the industries we studied. These data give some indication that firms' relationships with exchange partners preceded their acquisition of competitive capabilities.

¹⁰ We explored this alternative prediction by performing additional analyses using data capturing the percentage of a firm's total annual sales coming from its lead customer as a proxy for dependence. We regressed each of the capabilities on dependence, controlling for other significant predictors of the capability. The results show a negative and statistically significant relationship between dependence and both capabilities, contrary to what the theory would predict. The standardized beta coefficients for the dependence variable in the pollution prevention and quality management capabilities equations are -0.122 ($t = -2.077$; $p < 0.05$) and -0.113 ($t = -2.044$; $p < 0.05$) respectively.

¹¹ Dependence is positively correlated with two of the three attributes of embedded ties; information sharing ($\rho = 0.124$; $p < 0.05$) and joint problem solving ($\rho = 0.170$; $p < 0.01$).

acquire new capabilities may be dulled by the lack of competitive forces. Firms may be more inclined to upgrade and renew their capabilities when faced with the prospect of lead customers switching to alternative sources of supply.

The focus on small manufacturing firms may also be a limitation of our study and restrict the generalizability of the findings to this population. A replication with a different sample of firms would be a useful follow-on. In addition, it would be useful for future research to obtain performance data, which was difficult to obtain in our study since most of the firms were privately owned.

CONCLUSION

The overall picture emerging from this study indicates that embedded ties clearly matter for the acquisition of competitive capabilities. Firms do not acquire capabilities in isolation. Firms discover, evaluate, and learn how to implement capabilities in the course of interacting with key exchange partners. Chief among these exchange relationships are embedded ties with lead suppliers. In our study, well-developed joint problem-solving arrangements with key suppliers are an important driver of the acquisition of competitive capabilities. Hence, a firm's capacity to compete is a function of the types of exchange partners with whom it cultivates embedded ties and the quality of its interfirm exchange relationships.

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