Strategic Management Journal
Strat. Mgmt. J., **21**: 369–386 (2000)

REDUNDANT GOVERNANCE STRUCTURES: AN ANALYSIS OF STRUCTURAL AND RELATIONAL EMBEDDEDNESS IN THE STEEL AND SEMICONDUCTOR INDUSTRIES

TIM ROWLEY[1]*, DEAN BEHRENS[2] and DAVID KRACKHARDT[3]
[1]*Rotman School of Management, University of Toronto, Toronto, Ontario, Canada*
[2]*Department of Sociology, University of Toronto, Toronto, Ontario, Canada*
[3]*The Heinz School, Carnegie Mellon University, Pittsburgh, Pennsylvania, U.S.A.*

Network researchers have argued that both relational embeddedness—characteristics of relationships—and structural embeddedness—characteristics of the relational structure—influence firm behavior and performance. Using strategic alliance networks in the semiconductor and steel industries, we build on past embeddedness research by examining the interaction of these factors. We argue that the roles relational and structural embeddedness play in firm performance can only be understood with reference to the other. Moreover, we argue that the influence of these factors on firm performance is contingent on industry context. More specifically, our empirical analysis suggests that strong ties in a highly interconnected strategic alliance network negatively impact firm performance. This network configuration is especially suboptimal for firms in the semiconductor industry. Furthermore, strong and weak ties are positively related to firm performance in the steel and semiconductor industries, respectively.

hat long ago, the notion that firms improve ·mance by cooperating with competitors l have been viewed as an oxymoronic :. Currently in strategic alliances research, ver, cooperating with competitors is con-d to be potentially a valuable resource. ›ver, not only are particular dyadic strategic ;es competitive resources, but the pattern of ;ic alliances in an industry is also meaning-ı terms of competitive advantage (Dyer, Gulati, 1998; Jarillo, 1988; Madhavan, and Prescott, 1998). Because a strategic :e network leads to asymmetric access to ·ces across the industry, it can facilitate ıpede a firm's behavior and performance ovetter, 1985; Burt, 1992; Nohria, 1992). strategy researchers need to include the search for optimal network configurations: How should firms be embedded in the web of strategic alliances in their industries?

Gulati (1998: 296) illustrates that there are two types of network embeddedness relevant for addressing this question: relational and structural embeddedness.

> Relational embeddedness or cohesion perspectives on networks stress the role of direct cohesive ties as a mechanism for gaining fine-grained information ... Structural embeddedness or positional perspectives on networks go beyond the immediate ties of firms and emphasize the informational value of the structural position these partners occupy in the network.

Research, however, has produced contradictory and confusing implications regarding how firms should be embedded in networks. For example, both strong and weak ties—relational embeddedness—are argued to be positively related to firm performance. Strong ties are associated with trust and fine-grained information

vords: social capital; strategic alliances; net-:mbeddedness
spondence to: Professor Tim Rowley, Rotman School agement, University of Toronto, 105 St. George Street, ›, ON M53 3E6, Canada

›143–2095/2000/030369–18 $17.50

exchanges between partners (Uzzi, 1997; Larson, 1992; Krackhardt, 1992). On the other hand, weak ties lead to novel information (Granovetter, 1973). Similarly, the debate between Burt's (1992) structural hole and Coleman's (1988) closure forms of social capital illustrates that different types of structural embeddedness can be beneficial. Coleman (1988) argues that a dense network promotes trust and cooperation among its members. In contrast, Burt (1992) suggests that firms embedded in sparsely connected networks will enjoy efficiency and brokerage advantages based on the ability to arbitrage nonredundant information exchanges.

Recently, efforts have been made to reconcile these differences. Burt (1998) suggests that the two forms of social capital are not necessarily contradictory, but rather play different roles, which are valuable for different populations or purposes. In this paper, we utilize this contingency approach to explore the conditions under which sparse (dense) networks and strong (weak) ties are positively related to firm performance. We make two contingency arguments. First, relational and structural embeddedness have been treated as independent constructs in the literature. We argue that the interaction between these factors is an important explanatory variable: whether firms should form their strategic alliances through strong or weak ties depends on how it is structurally embedded in the network. One of the functions both relational and structural embeddedness serve is to act as a social control agent in terms of governing how alliance partners behave/cooperate. Thus, if a firm is already situated in a densely connected set of partners, is it still beneficial to be linked to the structure via strong ties? We argue that strong ties are less advantageous when the firm is situated in a dense network of alliances and that with respect to firm performance it is important to consider relational and structural embeddedness factors simultaneously. Second, we propose that the degree of uncertainty and required rate of innovation in the environment influence the appropriate network configurations. Firms operating in a rapidly changing environment will achieve competitive advantage through different forms of relational and structural embeddedness from firms in a stable environment. For example, our findings suggest that strong ties and dense ego networks are (independently) more advantageous in stable environments than weak ties, which are ben
when facing more uncertainty.

Overall, we have two goals in this paper.
we examine conditions under which strong
ties and sparse/dense networks are positively r
to firm performance. This increases our under
ing of how firms should be embedded in al
networks and contributes to resolving the
surrounding the different forms of social c
Second, we provide empirical support for the f
mental network view that alliance network
meaningful (Granovetter, 1985). That is, the m
in which a firm reaches its partners and the
and form of its network influence its perforn

The steel and semiconductor industries pr
an opportunity to empirically examine how
work embeddedness influences perforn
Manufacturing firms in both of these indu
utilize bilateral and multilateral alliances with
firms in order to execute components of thei
D and production activities. The research s
used for this examination involves separate al
networks for each industry. These networks c
of primarily horizontal alliances, which allow
to mitigate some of the effects power-relatec
tors can play in networks containing a dom
player among several overly-dependent subor
suppliers or distributors. An alliance is de
'as any voluntarily initiated cooperative agree
between firms that involves exchange, sharin
co-development, and it can include contribu
by partners of capital, technology, or firm-sp
assets,' including information and know
(Gulati and Singh, 1998). More specifically
strategic alliances comprising the networks in
cohesive/intense ties involving substantial in
ments such as equity ties, manufacturing
ventures, and joint R&D projects, and w
linkages, such as marketing and licensing a
ments and standards, and training arrangemen
the next section, we discuss the perforn
effects of relational and structural embedde
as described in the literature and then gen
hypotheses related to a discussion of their
action effects as well as the role played by
environmental context.

RELATIONAL EMBEDDEDNESS

Granovetter (1973: 1361) defines tie strength b
on a 'combination of the amount of time,

onal intensity, the intimacy (mutual confiding), he reciprocal services which characterize the For the purposes of examining interorgani- ıal networks characterized by horizontal :es, we measure tie strength by the frequency :eraction between partners and their level of :ce commitment to the relationship. Strong tie :es, such as equity arrangements, manufactur- ɔint ventures, and joint R&D projects, are ler and deeper' in terms of investment and ction than marketing joint ventures and tech- y licensing, which require less coordination or standing of partners' organizations (Powell, 314). The other dimensions—the emotional ity and intimacy—are pertinent for the indi- -level relationships central in Granovetter's) work, but are not as applicable to the rm horizontal alliances comprising this study. he literature, strong ties are shown to provide izations with two primary advantages. First, ; ties are associated with the exchange of ıuality information and tacit knowledge. Uzzi) observed in his study of the New York ɜl industry that firms participating in strong ere able to exchange fine-grained knowledge. development of strong ties, interfirm partners ıbout each other's organization, become more dent on one another and develop relational (Larson, 1992). Based on a deeper under- ng of a partner's operations, tacit knowledge ıre readily transferred across organizational aries, which are blurred by close contact ; and Johanson, 1983).

ond, strong ties serve as part of the social ıl mechanism, which governs partnership iors. Firms enter strategic alliances with ɜtitors to gain access to external resources, risks and cost, or pool complementary skills doorn, 1993; Kogut, 1988; Hagg and Johan- 983). However, interorganizational alliances with potential hazards. Because interfirm orations do not possess the control and nation mechanisms governing hierarchies or ts, participating firms are susceptible to the ; associated with opportunism (Williamson, . Moreover, formal contracts are often inef- ɜ governance devices, because they cannot :over all contingencies and may even under- collaborative efforts (MaCaulay, 1963).

ɔon (1992) shows that strong ties incrementally te and, in turn enhance, trust, mutual gain, ıcity, and a long-term perspective. Consequently, partners are more likely to forego individual short-term interests, exercise voice (rather than exit), and develop joint problem-solving arrangements (Powell, 1990; Uzzi, 1996). Strong ties produce and are governed by relational trust and norms of mutual gain and reciprocity, which grow through a history of interactions (Larson, 1992; Powell, 1990). Similar to Powell's (1990) assertion that networks represent a separate and distinct organizational form, Uzzi (1996) refers to this alternative governance system based on trust as the logic of embeddedness, and argues that it is the product of cohesive/intense ties. Similarly, Kale, Singh, and Perlmutter (2000) find a positive relationship between relational capital—strong ties based on trust—and the degree of learning in interfirm alliances.

These strong tie benefits—fine-grained information exchanges and trust-based governance—are different from the advantages gained through weak ties. Granovetter (1973) argues that weak ties are conduits across which an actor can access novel information. Weak ties are more likely than strong ties to be 'local bridges' to distant others possessing unique information. The strength of weak ties argument is as much about structural embeddedness as it is about relational embeddedness. A weak tie can be beneficial, because it is more likely to embed an actor in (or provide access to) divergent regions of the network rather than to a densely connected set of actors. For example, according to Granovetter's (1973) argument, an actor's collection of weak ties is more likely to be a sparse structure reaching divergent regions of the surrounding network.

The substantial support for the benefits derived from both strong and weak ties suggests that neither type is unconditionally preferred. Indeed, strong and weak ties have different qualities, which are advantageous for different purposes. While a firm is likely to have a mix of strong and weak ties, we argue it will benefit from a portfolio of ties favoring one type more than the other depending on the conditions surrounding the firm. Below we generate hypotheses related to some of these conditions.

REDUNDANT GOVERNANCE MECHANISMS

We have outlined the main effects of relational embeddedness on firm performance using existing theories to argue that strong ties act as governance mechanisms for interfirm alliances. However, structural embeddedness can also be examined in terms of its governance implications. Meyer and Rowan (1977) and Oliver (1991) argue that ties between actors facilitate the diffusion of norms across the network and, as a result, firms embedded in highly interconnected networks develop shared behavioral expectations (Rowley, 1997). Moreover, Coleman (1988) claims that dense connections between a set of actors govern (constrain) actions in the group and lead to cooperative behavior. 'If all firms in an industry had relationships with each other, interfirm information flows would lead quickly to established norms of cooperation. In such a dense network, information on deviant behavior would be readily disseminated and the behavior sanctioned' (Walker, Kogut, and Shan, 1997: 111). Kreps (1990) suggests that behaviors are controlled by a reputation effect: an actor is less likely to cheat an alliance partner, who is tied to the same third parties, because these mutual contacts will be aware of their actions.

Consequently, like strong ties, dense networks serve as a trust-based governance mechanism in interfirm alliances. However, in his review of the literature on trust, Hosmer (1995) identifies a distinction between trust in another actor's goodwill—willingness to consider a partner's interests—and system-level trust—the expectation that the system will function as designed. Strong ties produce goodwill between partners based on interdependence and a history of reciprocity and mutual forbearance. In dense structures, firms must deal with established expectations and well-organized partners, who are capable of punishing disobedience (Coleman, 1988). Firms trust that the network will facilitate collective monitoring and sanctioning, and produce effective incentives for cooperation. While interconnectedness involves norm creation at the network level, relational embeddedness creates trust at the dyadic level. Interconnectedness and strong ties lead firms to trust different aspects of their networks, but both serve as governance mechanisms in interfirm alliances.

Thus, when a firm is embedded in a dense structure, does it gain any extra benefits from strong ties with its direct partners? We argue that interconnectedness and relational embeddedness are, to some degree, substitutes for one another. Because a firm already benefits from the g(ance mechanisms supplied via the dense ne the firm will gain much less from strong tie dense network than when its partners are sp connected. The structure itself has pro behavioral norms to guide actions. As a by accessing the network predominately th strong ties, the firm is overcommitted or ov bedded for the purpose of governing exchange. Thus, a firm might be better off lishing other ties to nonredundant actors, than investing the time and resources requi form and maintain strong ties. This is not t that a firm's set of opportunities and const are the same whether it is surrounded by d connected partners or has highly cohesiv with its partners. There are still advantag cohesive ties. As discussed above, the qual information exchanged in close ties is deem be more fine-grained than in less co alliances. Nevertheless, the impact of stron on firm performance is not as dramatic whe structure of the firm's ego network is com of a highly interconnected set of partners. argument leads to the following hypothesis

Hypothesis 1: The positive relatio between strong ties and firm performa greater in sparse ego networks than in ego networks.

EMBEDDEDNESS IN DIFFERENT ENVIRONMENTAL CONTEXTS

The debate surrounding social capital is cent understanding how a firm should be struct embedded in its industry's web of str alliances. Social capital theorists agree that who are better connected to the network h competitive advantage over poorly conn actors. However, there is much disagree regarding what it means to be 'better conne (Burt, 1998). Coleman's (1988) closure ment, which states that actors are better c dense networks, is in complete contrast to I hole argument, prescribing firms to embed t selves in a sparse network of disconnected ners. This debate is problematic for exam how firms should be embedded in their stra alliance networks. Burt (1998) suggests a co gency approach for reconciling the debate. In 'guing for unconditional superiority of one over the other, Burt (1998: 45) argues that: ; closure and hole arguments are not as adictory as they might seem . . . The ambi- stems in large part from the different roles social capital plays in the study populations which each is justified.' In other words, s (1992) and Coleman's (1988) versions of l capital provide different benefits, which are l for different strategic purposes. We will ibe these distinct benefits and propose con- is under which firms will be 'better connect- ia the hole and closure forms of social capi-

mentioned above in the discussion of redun- governance, Coleman (1988) argues that one benefits of dense ties among a group of ; (closed network) is collective social capi- which promotes shared behavioral norms ley, 1997) and cooperation (Walker *et al.*,). Competitive firms within a dense clique ategic alliances can rely on its partners to esce to the group's cooperative norms. On ther hand, firms occupying many structural —the positions between other actors who ot directly linked—enjoy efficiency and con- benefits. Ties to multiple actors, who are cted to one another, provide redundant nation (Granovetter, 1973; Burt, 1992). ver, a firm occupying many structural holes ew redundant ties and economizes on the er of ties required to access unique infor- n. Further, firms situated in structural holes warded control benefits because they act as iediaries between disconnected partners, ely on the firm to facilitate exchange flows the network. Thus, dense networks are tageous for developing trust and cooperation gh collective monitoring and sanctioning, but provide redundant information from multi- urces. In contrast, a sparse network provides with the ability to efficiently obtain and information (resources), but the structure not generate a governance mechanism to e opportunism. A firm occupying many iral holes will have an advantage over its titors who rely on it to send and receive iation and resources in the network of stra- illiances. Thus, to understand how firms can competitive advantages through structural ldedness, we need to consider the conditions which firms are better off possessing the distinct benefits found in these different structures and forms of social capital.

One of the conditions influencing the types of advantages firms require is the degree to which their strategies are designed to exploit existing technologies, skills, and information, or explore the environment for emerging innovations and other significant changes. March (1991: 85) claims that 'the essence of exploitation is the refinement and extension of existing competencies, technologies and paradigms. The essence of exploration is experimentation with new, uncertain alternatives.' While exploitation involves using existing information to improve efficiency and returns from present strategies, competencies, and procedures, exploration entails searching and experimenting to find emerging innovations that will produce future profits. March (1991) argues that both processes are required and often occur simultaneously, but compete for limited resources. Strategic decisions surrounding these activities involve a trade-off of how much to invest in the refinement of existing technologies to reap profits today, compared to the invention of new technologies to secure returns in the future when environmental conditions demand new strategies (Levinthal and March, 1981). The proportion of resources allocated to exploitation and exploration differs across environments: the degree to which firms favor one activity over the other depends on environmental conditions. For instance, environmental uncertainty influences the degree to which firms must refine existing technologies and/or seek out new opportunities. In unstable environments firms must allocate more resources toward exploration than in more stable environments in which there is less uncertainty about future directions and fewer environmental disturbances (Lant, Milliken, and Batra, 1992). The existence of environmental uncertainty increases the rate of innovation required to survive and therefore how much firms invest in exploration. Furthermore, as different environments mandate distinct mixtures of exploitation and exploration, the type of social capital that will be advantageous will also change.

The appropriate type of social capital for firms to embed themselves in is influenced by the diverging information requirements between exploitation and exploration. In exploration, the focus is on gathering new information on many different alternatives. Information is relatively broad and general in nature, because the emphasis is on identifying viable alternatives rather than fully understanding how to develop any one innovation. Thus, explorers concentrate on broad searches. This task does not have a well-defined solution space so firms perform broad searches of their environments in order to identify a variety of future options. For example, Toyota's suppliers turn to a large and diverse network of other actors to learn about industry and environmental trends, which might trigger new directions (Dyer and Nobeoka, 2000). In the exploitation mode, however, the emphasis is on refining an existing innovation by gathering specific information that will provide deeper knowledge in that particular area. In other words, the solution space for an exploiter's environment is well defined and limited. As a result, exploiters perform deep searches of this limited solution space. Compared with exploration, exploitation requires a deeper understanding of specific information rather than a wider grasp of general information. In the Toyota supplier network, Dyer and Nobeoka (2000) report that core groups of five to seven suppliers sharing common operations (*jishuken* groups) work closely together to facilitate the creation and 'transfer of tacit knowledge' and experiences on how to make cost reduction improvements. This type of knowledge sharing assists each supplier to more fully exploit its core innovation.

Because explorers place a premium on newer, more general information and have not invested in any one direction, they can tolerate some information noise in order to access a wider breadth of sources. However, as a firm moves from the exploration to the exploitation stage, it shifts from general to specific information and is less tolerant of information noise. The differences between the information requirements for exploitation and exploration lead to different structural embeddedness prescriptions. For firms operating in relatively uncertain environments demanding more exploration for new innovations and alternative strategic directions, dense connections are constraining. Nahapiet and Ghoshal (1998: 245) argue that the collective social capital resulting from dense networks can limit a firm's 'openness to information and to alternative ways of doing things, producing forms of collective blindness that sometimes have disastrous [effects].' As norms diffuse across a dense network, deviant behavior, regardless of its value to network members, is curtailed and, as a result, innovat suppressed (Coleman, 1988). Burt (1992) that connections to a group of partners wl connected to one another provide redundant mation and limit the firm's access to div perspectives and sectors of the environme fact, Burt's (1992) structural hole arg stresses that the optimal network positic gaining access to unique information occurs a firm's partners are not connected to one a or similar others. A firm gains unique inforr and perspectives from each of its partne occupying structural holes. Thus, in unc environments demanding relatively high i ments in exploration, low-density network tures are preferred.

Hypothesis 2: For firms in environ demanding relatively high investmen exploration, the density of ties among a direct partners is negatively related to it formance.

Although firms that invest heavily in exploi activities are likely to internalize the innovation/technology, they still utilize ex ties for the purpose of accessing knowledg will help them refine their technologies an operating costs. Mowery and Rosenberg (argue that internal activities and intero zational ties are not substitutes, but rathe important and necessary complements. 'In capability is indispensable in evaluating res done outside, while external collaboration vides access to news and resources that cann generated internally' (Powell, Koput, and S Doer; 1996: 119). 'External linkages are *both* a means of gaining fast access to know and resources that cannot be secured inte *and* a test of internal expertise and learning bilities' (Powell and Brantley, 1992: 371).

Moreover, there is evidence that firms inv heavily in exploitation form external ties to plement and evaluate internally generated k edge. Dyer and Nobeoka (2000) found that ota's suppliers participate in voluntary lea teams in which they review other suppliers' ations and provide advice on cutting costs. larly, von Hippel (1998) illustrates that engi from rival firms in the steel industry est informal linkages across which they excl information on how to reduce production

, firms are not internalizing activities as comly as what might be expected within a transn cost framework (Powell and Brantley,). Instead, firms use both external ties and ıal ties in order to exploit existing technol- and improve operations.

'ormation requirements in the realm of ıitation—more specific know-how about a :ular innovation—are better extracted from : network structures. Moreover, because they invested in and committed to one direction, are less tolerant of information noise. Inforın theorists argue that information noise is ed and more exact information is obtained multiple and redundant sources are accessed ınon, 1957). The ability to triangulate among ple sources allows firms to evaluate the nation obtained and gain a richer understing. Moreover, connections among a firm's ɜrs mean the firm receives redundant inforn from those partners who are inter:cted. Thus, for the purpose of exploiting ng innovations, dense networks assist firms taining a deep understanding of a specific ation in order to refine and improve it.

pothesis 3: For firms in environments nanding relatively high investments in ›loitation, the density of ties among a firm's ect partners is positively related to its permance.

ldition to density, we argue that the ıtation/exploration categorization is useful nderstanding the conditions under which ; and weak ties are advantageous. As men- above, the exploitation of existing inforn requires deeper knowledge specific to the current direction. Uzzi (1996) illustrates rms receive this type of information through e linkages. Although strong ties require frequent interactions and commitment of ces (Granovetter, 1985; Krackhardt, 1992; , 1988), strong ties provide rich exchanges ;tomized information. Thus, we expect that ties are especially important for the pur- ɔf exploitation.

he exploration mode, a firm does not require ɔer knowledge of a specific innovation that ained through strong ties. Moreover, the and resource obligations of strong ties ıared to weak ties) diminish the number of contacts a firm can realistically maintain and therefore limit its reach into divergent sectors of the environment. As such, exploration through intense ties decreases the number of alternative innovations identified in the environment. Moreover, one of the implications of Afuah's (2000) study of alliances among computer workstation manufacturers is that a firm operating in a turbulent environment (rapid technological change and obsolescence) should not invest all of its alliance resources in strong ties to a small set of suppliers and horizontal partners. A technological shock could dramatically impede its competitive advantage, because it is overcommitted to the strategic position established through its close partners. Thus, firms need to allocate resources to maintaining at least weak relationships with alternative partners, who represent options for dealing with environmental shocks. Overall, the relationship between tie intensity and firm performance depends on whether the environment demands a relatively high degree of exploitation or exploration.

Hypothesis 4: For firms in environments demanding relatively high levels of exploitation, the number of strong ties a firm has with its strategic partners is positively related to its performance.

Hypothesis 5: For firms in environments demanding relatively high levels of exploration, the number of weak ties the firm has with its strategic partners is positively related to its performance.

Hypothesis 6: For firms in environments demanding relatively high levels of exploration, the number of strong ties a firm has with it strategic partners is negatively related to its performance.

THE EMPIRICAL STUDY

Network selection

In an effort to construct accurate maps of strategic alliance networks, we focused on two industries: one network was constructed for the steel-producing industry and the other for the semiconductor-manufacturing industry. One of the challenges in performing network studies is adequately specifying the boundaries of the network (Gulati, 1995; Oliver, 1991). Because both industries in this study were capital and knowledge intensive, firms tended to be large players, who focused exclusively on steel (or semiconductor) manufacturing or had dedicated, distinct business units in these areas. The existence of large firms and few peripheral players straddling the boundaries of these industries provided a reasonably clear picture of the firms in each industry (Gulati, 1995). Marsden (1988) and Knoke (1994) summarized three decision rules used for constructing networks for empirical examination and defining boundaries: attributes of actors, such as membership in an organization or industry; types of relations between actors, such as strategic alliances or interlocking directorates; and participation in a set of events or issues, such as proposed plans to deregulate a highly regulated industry. Moreover, Doreian and Woodard (1994) argue that relational criteria alone are often not sufficient for the purpose of specifying network boundaries. Consequently, for each industry the sample was designed based on two criteria: membership in the target population (industry) and at least one strategic alliance with another member of that industry. Industry membership was determined by SIC codes. The strategic alliance networks in the steel and semiconductor industries were constructed by replicating Hagedoorn (1993) and Hagedoorn and Schakenraad's (1994) relational data technique, which has recently gained popularity in management research (Gulati, 1995; Madhavan, 1996).

Semiconductor network

Relational data for the semiconductor industry were collected from multiple sources, which provided an opportunity to verify the data. One valuable source was CMP Media Inc.'s Web site (www.techweb.com). CMP is a publishing firm with 15 magazines dedicated to reporting information on firms and events related to computers, electronics, information technology, and the Internet. The Web site offered a complete data base of CMP news stories from 1994 to 1997, which was used to identify participants in semiconductor strategic alliances. A total of 6571 reports of relationships between high-tech firms were identified and 419 of these reports represented strategic relationships between semiconductor To verify these data and collect relational for the period 1990–94 (a period not cover the CMP data base), we consulted the *Do Strategic Partnership Report*, an extensive base and analysis of relationships among tech firms from 1990 to 1996. Domicity's r which contained information on 1754 ties also used to verify the CMP data becaus two sources' data overlap from 1994 to This second data source provided 109 addi strategic alliances among semiconductor which were not part of the CMP data set. Fu more, the two independent reports were for gaining a general estimate of the relia of the data collection method: There was percent consistency in the relationships rep by these two sources for the period of covered by both data sets. In addition to data sources, we consulted two industry ana Each expert was given a report on the sem ductor relationships captured in the data set asked to identify errors—missing relatio reported relations that did not actually between firms.

Steel network

Relational data for the steel industry were lected from the *Dow Jones News Retrieval vice*, the *Globe and Mail* data base and trade publications, such as *Metal Bullet* global news journal for the iron, steel, and ferrous metal industries. The data colle technique for the steel industry parallele procedure used for the semiconductor ind and spanned the same time period (Janua 1990 to June 30, 1997). Additional relatio data, and verification of the data gathered secondary sources, were gained from a pre network study of the steel industry. Madha (1996) data base consisted of relation formed among steel-producing firms from and 1993. These data represented 3000 re from the *Dow Jones News Retrieval Se* which were transformed into a network of strategic alliances.

Industry experts were used to verify the gained from these sources. There were 15 e identified by these experts, who also assiste dealing with each of these discrepancies addition, there was a 1-year overlap betwee data sources and 94 percent consistency in ·elationships reported.

use there are different types of strategic ıces, researchers must decide how to measure tie type. Contractor and Lorange (1988) :ructed an ordinal scale, which assigns hts to each alliance type based on the sity/strength of the linkage. This treatment ıta is appropriate for the purpose of iden- ıg and describing the structural elements of twork, such as mapping strategic groups ria and Garcia-Pont, 1991). To understand ›ehaviors and performance of firms in the ɔrk, however, it is important to perform a fine-grained analysis of alliance data. ;ning the highest weight for multiple ıces between a pair of actors assumes that g and weak ties are different in degree only. is, the types of behaviors associated with a g tie are the same as a weak tie, only more se. Several researchers, however, argue that ıature of weak and strong ties is different nd as well as degree (Granovetter, 1985; chardt, 1992; Uzzi, 1996). Strong ties do not ıble weak ties—they serve different purposes ·equire a different set of alliance behaviors. by treating strong and weak ties as separate ructs rather than degrees of one another, we re a richness in the data, which past rchers deem important in understanding net- effects and firm behaviors.

: collected alliance data on several types of gic ties based on categories adapted from ·actor and Lorange's (1988) scheme. While treat the categories as an ordinal scale, we ate these alliance types into two groups: and strong ties. There is a natural demar- ı among these ties based on the resources ıitted to the alliance. In addition to a sub- ally higher level of resource commitment, ılliance types in the strong tie category ·e 'up front' resources and significantly more ɜnt interactions. Partners must invest in the ce before realizing any benefit and maintain ır interactions to yield those benefits. The ces under the weak tie category require a ıntially smaller resource commitment from artners, and these ties are closer in nature arm's length transaction in which there is an instant (in relative terms to strong ties) exchange of value. Moreover, alliances in the weak tie class require less coordination of activities across firms and therefore less interaction in terms of frequency and depth. Thus, equity alliances, joint ventures, and nonequity cooperative (R&D) ventures are categorized as strong ties, and weak ties are operationalized as marketing agreements, and licensing and patent agreements.

In addition, Figure 1 displays the distribution of alliance types for both industries. Interestingly, the shapes of the distributions are approximately equal. Nonparametric tests of the homogeneity of distributions (Marascuilo and Serlin, 1988: 360) reveal that the overall distributions are different, but the distribution of alliances within strong ties and within weak ties are not significantly different. Thus, there is some evidence that the composite measures of strong and weak ties are similar across industries.

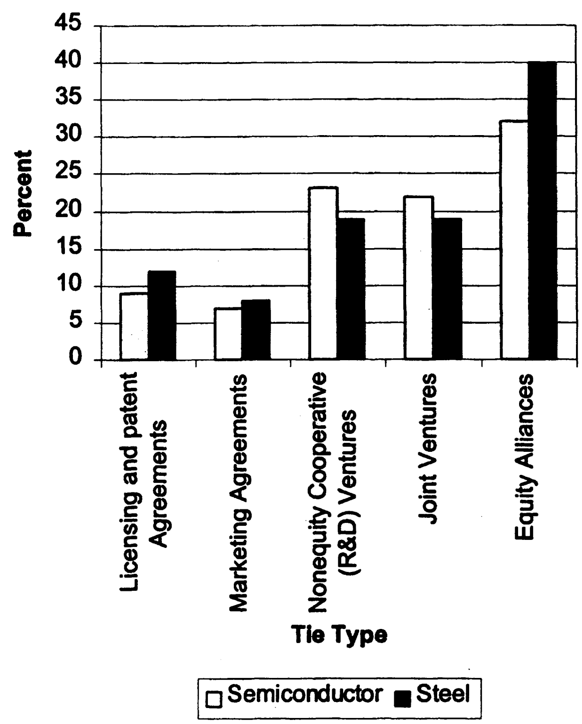

Figure 1. Distribution of alliance types

Measures

Construction of social network matrices

To calculate structural measures, symmetric (nondirectional) matrices were constructed (Scott, 1991; Wasserman and Faust, 1994). Two matrices—steel and semiconductor industries—were constructed. To calculate density, we dissected the network into smaller ego networks to find local (and unique) densities for each firm in both networks. Local density examines the interconnectedness of relationships among a focal firm's direct partners. Furthermore, the focal firm and its relationships were excluded from the local density calculations. 'In an egocentric network it is usual to disregard the focal agent and his or her direct contacts, concentrating only on the links which exist among these contacts' (Scott, 1991: 75). In addition, local densities were measured using the aggregate network of both strong and weak ties.

A local density rather than a global measure—overall density for each network—was used because the theories underlying our hypotheses are more closely connected to ego networks. One of the theoretical themes underlying density is that a given firm's behavior is influenced by the structure of ties among its direct partners. Indeed, Coleman's (1988) closure argument suggests that a focal actor whose direct partners are densely connected to one another will need to cooperate to avoid negative sanctions from the tightly linked collective. Our local density measure is consistent with this logic.

Global density, however, is less compatible with the theory supporting our hypotheses. First, the supporting theory does not suggest that the overall interconnectedness of the network will impact behaviors. Moreover, the density of ties in distant regions of the network will not dramatically influence behaviors in a given actor's ego network. Garcia-Pont and Nohria's (1999) findings are supportive of the notion that global density is less influential on firm behavior. While local density and past ties predict the formation of a tie between a given pair of firms in the global automotive industry, their data suggest that global density is not a significant factor. For the purposes of this study, a firm's density (DENSITY) was measured as the number of existing ties in the ego network (other than those involving the focal organization), divided b total possible number of ties among its pa if each partner were tied to every other pa

A dummy variable was utilized to captur ferences between industries, including globa sity (INDUSTRY). Steel and semiconductor were assigned a value of 1 and 0, respect In addition, we controlled for firm (LNASSETS) and country of (COUNTRY). Finally, firm performance operationalized as return on assets (ROA).

Exploitation/exploration

As mentioned above, firms facing a high d of environmental uncertainty will need to i more in exploring new opportunities and vations than firms facing stable environme which they can allocate more resources to e existing technologies. Thus, following La *al.*'s, (1992) approach to comparing firms f different degrees of environmental turbulenc examine firms (and their networks) in industries—steel and semiconductor—exhil different degrees of environmental uncertai order to investigate embeddedness effects a contexts requiring different mixes of explo and exploitation. These industries diffe environmental uncertainty in terms of the env mental complexity, and predictability and quency of change (Dess and Beard, 1984), v translate into different strategic investments.

First, over a 10-year period ending in the variation on sales, which captures the dictability dimension of the environment (and Beard, 1984, Lant *et al.*, 1992), was si cantly larger in the semiconductor industr was more difficult for semiconductor firm gauge future sales levels for existing pro and markets than in the more stable steel ind The steel industry, which epitomized the st typical mature industry, was characterized relatively fixed product/market mix, few pr innovations, and few new entrants. These fa lead to relatively infrequent changes in environment. The only dramatic environm change punctuating the stable steel industry the past decade was the introduction of the C pact Strip Production process employed in r mills (Ghemawat, 1993). This environm shock reduced costs, especially on custom involving relatively smaller quantities than in the integrated steel production process. ontrast, owing to rapid technological change product obsolescence, as well as the continual :gence of new markets, the semiconductor stry has been characterized as a volatile :onment (Hannan and Freeman, 1989). The ɹtion of technologies, including converging ıologies, translated into relatively uncertain :hanging markets, which demanded that firms ibrate their competitive advantages to fit : changes.

ıe *Directory of American Research and Techgy* (Bowker, 1995), which describes research development activities of American corpons, was useful for illustrating this difference een the steel and semiconductor industries. bset of 40 steel and 28 semiconductor firms :sented in the networks was identified in directory (see Table 1). The percentage of oyees with Ph.D. degrees on staff was simiı the semiconductor and steel industries: 14.8 :nt and 12.9 percent, respectively. However, verage number of different Ph.D. specialties ıe semiconductor, 5—chemical, electrical, 'are and systems engineering, and physics— twice that of the steel industry—chemical, :ical engineering, and metallurgy. Also, the number of different Ph.D. specialties in the :onductor industry was 14, but only 6 for firms in the sample. This comparison proevidence, albeit on a subset of U.S. firms, steel and semiconductor firms operate on :ent levels of environmental complexity. , there is evidence for semiconductor firms g more complexity, which is measured by ıeterogeneity and range of organizational ıties or specialties (Dess and Beard, 1984).

1. Differences in range and type of research :ies

	Semiconductor	Steel
Ph.D.s on R&D staff	14.8	12.9
ge # of Ph.D. lties on staff	5	2.5
gate # of Ph.D. lties listed	14	6
firms performing ;s-oriented R&D	36.6	100.0
firms performing :t-oriented R&D	98.0	23.7

Firms had to monitor vast environments, exploring new applications of their technologies and complementary technologies developing from a combination of a diverse set of specialties. The direction of changes was often unknown and the product/market combinations are less stable than the steel industry.

These diverging conditions across the semiconductor and steel industries translated into different degrees of product and process R&D. The percentage of firms reporting process and product-oriented efforts were 36.6 percent and 98 percent, respectively, in the semiconductor industry (see Table 1). In the steel industry, 100 percent of the firms reported process-oriented research and development, but only 23.7% claimed product-based activity. Relative to the semiconductor industry, competitive behavior and advantage focused on the exploitation of existing technologies and skills in long-standing markets and products rather than experimentation with emerging technologies or markets. Indeed, the bulk of research and development focused on process innovations designed to reduce costs. Von Hippel (1988) surveyed plant managers in U.S. minimills, asking them if their firms develop proprietary process (improvements) or product innovations that would be valuable to competitors and whether they share that information with competitors. The results indicated that steel firms develop and share process-oriented innovations. Because steel firm products are mostly 'commodities, it is logical that process innovations that save production costs will be of significant value to innovating firms and of significant interest to competitors' (von Hippel, 1988: 80). Because the product/market combinations in the steel industry were well established and the frequency of change was low, firms' competitive moves focused on cost reduction and efficiency (Knoedler, 1993). As a result, steel manufacturers concentrated on improving existing technologies more than searching for new technologies. Thus, based on the differences between these two industries as outlined in Table 1, exploitation of the environment is more common and more important in the steel industry than in the semiconductor industry. Conversely, with the focus on new product development within the semiconductor industry, we have support for the assertion that exploration is integral to the semiconductor activities.

RESULTS

Table 2 presents the descriptive statistics for the relational variables of interest; namely, total number of strong and weak partners, total number of strong and weak ties (i.e., SUM_STRG and SUM_WEK, respectively); financial performance (e.g., net income and ROA); as well as the structural variable of interest (e.g., DENSITY) for the steel and semiconductor industries; and Table 3 illustrates the correlations among these variables.

To examine the relationships among relational and structural embeddedness and firm performance, we constructed three OLS regression models (Table 4). Models I and II examine the influence relational embeddedness—strong (STRONG TIES) and weak (WEAK TIES) ties—and structural embeddedness—density (DENSITY)—have on firm performance, while controlling for industry and size effects. There is a significant negative relationship between the number of strong ties a firm has and its performance ($p < 0.05$), and a significant positive relationship between the number of weak ties it has and its performance. In other words, for these data consisting of horizontal ties among manufacturing firms in two separate industries, there is a general positive relationship between the number of weak ties and ROA, which supports Granovetter's (1973) weak tie argument. However, the strong tie argument is not supported. Moreover, when examining the interaction effects of industry on strong and weak ties, we find that in the exploitation context (steel) strong ties are positively related tc formance ($p < 0.05$). This point provides in support for Hypothesis 5, which is directly in Table 5.

In Model II, we examine the influence c structural embeddedness factor on firm per ance, but find support for neither Burt's (hole or Coleman's (1988) closure argu Although DENSITY is negatively related tc performance, the result is not statistically si cant. Model II displays the OLS regre involving density (interconnectedness) and] Interconnectedness does not have any signi effect on ROA.

In order to determine whether relational er dedness is moderated by structural embeddec we examine DENSITY, STRONG TIES, WEAK TIES together in Model III (see Tab In addition, we are also interested in the po differential effects due to industry, so the du variable for industry was also included. Thu examine the main effects due to tie type network structure as well as industry. Althou Model I STRONG TIES is significantly relat ROA, in Model III the direction is still neg but it is no longer significant. Conversely, W TIES is still significant in Model III and l positive impact on ROA. The main effect d industry is still negative in Model (as it is in both Models I and II), b is a significant finding. In exam Hypothesis 1, namely that the interaction of th governance mechanisms—relational and stru embeddedness—will reduce performance, we

Table 2. Total industry descriptive statistics

	Steel					Semiconductor				
	N	Max.	Min.	Mean	S.D.	*N*	Max.	Min.	Mean	S
# of ties	138	24	0	3.51	4.15	132	62	1	8.05	13
DENSITY	77	1	0	0.506	0.416	90	1	0	0.409	C
Net income (millions of $)	41	7510.0	−350.7	376	1202.4	38	1318.0	−593.0	151.8	351
ROA	58	0.22	−0.54	0.040	0.103	66	0.70	−0.03	0.064	C
SUM_STRG (Total # strong ties)	138	19	0	3.10	3.59	132	46	0	4.27	8
SUM_WEK (Total # weak ties)	138	7	0	0.406	1.04	132	28	0	3.77	5
# partners strong	138	12	0	2.74	2.81	132	26	0	3.18	5
# partners weak	138	6	0	0.377	0.914	132	17	0	2.95	3

Table 3. Correlations

	LNASSETS	COUNTRY	DENSITY	INDUSTRY	STRONG	WEAK	DEN*STRG	IND*STRG	DEN*IND	DEN*WEK
LNASSETS										
COUNTRY	−0.259*									
DENSITY	−0.264*	0.101								
INDUSTRY	0.050	−0.083	0.131							
STRONG	0.100	−0.064	−0.236*	−0.089						
WEAK	0.125	−0.015	−0.254*	−0.389*	0.673*					
DEN*STRG	−0.022	−0.017	0.176	0.041	0.810**	0.419*				
IND*STRG	0.118	−0.080	−0.151	0.518**	0.287**	−0.138	0.155*			
DEN*IND	−0.049	−0.039	0.652**	0.697**	−0.074	−0.252*	0.211**	−0.268*		
DEN*WEK	0.044	0.034	0.045	−0.513*	0.540	0.853**	0.361**	−0.248	−0.275**	
IND*WEK	0.117	−0.067	−0.141	0.265	0.141	0.062	−0.065	0.498**	0.082	0.025

**Correlation is significant at the 0.01 level (2-tailed)
*Correlation is significant at the 0.05 level (2-tailed)

Table 4. Determinants of return on assets

Variable	Relational embeddedness	Structural embeddedness	Interaction
(Constant)	0.0148	–0.0581	0.0022
LNASSETS	0.0002	0.0057*	0.0031
COUNTRY	0.0015	0.0075*	0.0008
DENSITY		–0.0341	–0.0032
INDUSTRY	0.0206	–0.0124	–0.0798**
STRONG TIES	–0.0059**		–0.0025
WEAK TIES	0.0108***		0.0073**
DENSITY*STRONG			–0.0124*
INDUSTRY*STRONG	0.0094**		0.0141***
INDUSTRY*STRONG*DENSITY			–0.0069
DENSITY*INDUSTRY		0.0239	0.0999*
DENSITY*WEAK			–0.0007
INDUSTRY*WEAK*DENSITY			–0.0479
INDUSTRY*WEAK	–0.0035*		–0.0017
N	120	98[a]	98
R^2 (adjusted)	0.3550	0.3500	0.454

*–α < 0.1; **–α < 0.05; ***–α < 0.01
[a]The inclusion of interaction partners density (DENSITY) reduces the degrees of freedom from 120 to 98. Tho organizations who were connected to isolates had a density measure which was undefined, and were dropped from the an

Table 5. Exploitation/exploration environments

Variable	Beta coefficient	
	Steel (Model IV exploitation)	Semiconductor (Model V exploration)
(Constant)	–0.0330	–0.0628
LNASSETS	0.0011	0.0056
COUNTRY	–0.0024	0.0030
DENSITY	0.0901**	0.0024
STRONG TIES	0.0119***	–0.0028
WEAK TIES	0.0057	0.0074**
DENSITY*STRONG	–0.0168*	–0.0109**
DENSITY*WEAK	–0.0491	–0.0005
R^2 (adjusted)	0.4360 $N = 53$	0.4530 $N = 45$

*–α < 0.1; **–α < 0.05; ***–α < 0.01

that the interaction effect of DENSITY*STRONG is significant and negatively related to firm performance. This result provides support for Hypothesis 1, however only at $p < 0.10$.

The hypothesized relation (Hypotheses 2 and 3) between the interaction of density and exploitation/exploration (DENSITY*INDUS1 is not directly tested in Model III. How the interaction effect of these two variabl significant ($p < 0.10$), which implies that formance is more positively affected by de in the steel industry than in the semicond industry. In order to directly test Hypothes and 3, Models IV and V were created (Tab and are discussed below.

Hypothesis 5—INDUSTRY*STRONG sh have a positive effect—is not directly teste Model III. However, we find that when comp with the exploration environment, the exploit context does have a significantly greater pos effect on ROA owing to strong ties. To dir test Hypotheses 5 and 6 we must again exa Models IV and V. The interaction of ind and weak ties (INDUSTRY*WEAK) is not nificant and does not support Hypothesis 4. H ever, to directly test for this hypothesis we i examine Models IV and V.

Directly testing exploitation and exploratic

To further examine the actual differe between the two environmental contexts

:tly test Hypotheses 2, 3, 4, 5, and 6, rate regressions were run on each industry set. Model IV (see Table 5) examines the :ts of density, and strong and weak ties on performance in the steel industry. Simi- , Model V (see Table 5) examines the : variables in the semiconductor industry their effects on organizational perform- .

ie results from Model IV suggest that inter- ectedness is positively related to perform- for the purposes of exploitation. This orts Hypothesis 2. As in Model I, the ngs in Model IV support the contention in othesis 5 that strong ties are positively ed to performance in environments anding a relatively high degree of exploi- n. In addition, the results from Model IV ort Hypothesis 1, because the interaction involving density and strong ties NSITY*STRONG) is significant 0.10).

Table 5, Model V illustrates the regression ts specific to the exploration setting iconductor industry). Hypothesis 4 is sup- d ($p < 0.05$)—the number of weak ties a has with its strategic alliance partners is ively related to firm performance in environ- s demanding relatively high levels of explo- ı. The significant and negative relationship een the density and strong tie interaction 0.05) supports Hypothesis 2—strong ties in ıse network are negatively related to per- ance in this environmental context. How- the data do not support Hypothesis 6, h states that strong ties are negatively :d to firm performance in the exploration :xt.

CUSSION

study is useful for identifying sources mpetitive advantage in interorganizational orks by reconciling some of the competing nents surrounding how relational and tural embeddedness factors influence firm rmance. We consider the conditions under ı strong and weak ties (relational ddedness), and closed and sparse networks :tural embeddedness) are sources of com- ve advantage.

Relational embeddedness

As indicated in the results section, our findings in Model I (Table 4) support Granovetter's (1973) *strength of weak tie* argument: Weak ties are positively related to firm performance. However, the argument that strong ties can lead to effective interfirm linkages and competitive advantage because they build trust-based governance and lead to norms of reciprocity and mutual gain is not supported by the results in Model I. Indeed, strong ties are significant, but negatively related to firm performance in the two-industry sample. It is necessary to acknowledge that our theory is concerning, and the sample consists of, horizontal ties rather than vertical ties in supplier networks (Uzzi, 1996) or entrepreneurial settings (Larson, 1992). Our study offers some empirical support for a contingency-based argument, which suggests that both strong and weak ties are beneficial to firms, but under different conditions—for different purposes and at different times (Hite and Hesterly, 1999).

Although our results do not strongly support the theoretical arguments regarding the main effects of strong ties or density (for both industries combined), the findings do suggest that the interaction of these variables is relevant: a firm that is embedded in its industry's strategic alliance network via strong ties to its partners, who are densely connected to one another, is poorly situated in the network (see Table 4, Model III). According to the theory developed in this study, dense interconnections and strong ties are alternative social control mechanisms, which in combination provide little additional benefit. Because there are costs associated with forming and maintaining strategic ties, especially strong ties, the utilization of strong ties in a dense network takes resources away from other functions that can add value to the firm. Thus, with reference to prior research regarding the roles and advantages of strong and weak ties (Uzzi, 1996; Granovetter, 1985), and structural embedded variables (Burt, 1992; Coleman, 1988), such as interconnectedness, it is important to consider these features in tandem. In other words, the roles that interconnectedness and tie intensity play in firm performance depend on each other, and therefore discussing these features independently may be misleading. However, given the interaction is only significant at $p < 0.10$, further study is required to verify/refute this relationship.

In addition, relational embeddedness effects are not only contingent on structural embeddedness, but also on the environmental context. The findings support our claims that strong ties are positively related to firm performance when the environment demands a relatively high degree of exploitation (Hypothesis 5), and weak ties are beneficial for exploration purposes (Hypothesis 4). However, we do not find support for the notion that strong ties are detrimental in the exploration context. Although past research convincingly argues that tie intensity and performance are positively related (Uzzi, 1996; Larson, 1992), our study of strategic alliance networks suggests that the nature of this relationship depends on the environmental context. We suggest that the weak and strong tie arguments need to be bound by particular populations and/or purposes. For example, our study suggests that the strong tie argument is credible when dealing with lower environmental uncertainty and a competitive environment demanding a high degree of exploration. Moreover, our results provide support for the weak tie argument, especially within an uncertain environment, which demand more exploration into new innovations and alternative strategic directions.

Theoretically, these results are insightful for understanding the different network requirements for exploration and exploitation. The need for deep/specific knowledge in the exploitation mode is well served through strong ties. Strong/cohesive ties, which produce thick information exchanges (Larson, 1992), trust, and joint problem solving (Uzzi, 1996), assist exploitation-focused firms in gaining organizationally embedded know-how. However, for the purpose of exploring the environment for new innovations and unique information this study supports the argument that additional weak ties lead to higher performance.

Social capital

In Model II (Table 4), we do not find support for either Burt's (1992) structural hole argument or Coleman's (1988) closure argument because density is not significantly related to firm performance. Nonetheless, consistent with Burt's (1998) claim that the debate between these seemingly competing notions of social capital can be reconciled by considering the study population, we examine structural embeddedness in environmental contexts. Despite this nonsi cant main effect, there is support for our hy esis postulating that density is beneficial i exploitation context. However, the results d allow us to comment beyond our theoretical ment regarding the negative role density pla the exploration setting (hole argument). I exploitation model (steel industry), the fin suggest that dense ties among a firm's stra partners could be a source of competitive a tage (closure argument).

Like tie intensity, the influence of connectedness among a firm's alliance pa can only be appreciated with reference t industry context. The hole argument states density has a negative effect on perform because the probability that a firm will opportunities to access and broker unique i mation diminishes as interconnectedness incr (Burt, 1998: 13). However, the results in study do not support this logic. Again, it i industry context that determines whether i connectedness influences performance. Depe on the extent to which a firm is engage exploitation or exploration, its purpose accessing its network will change. As a r how structural embeddedness factors infl firm performance will also change. Inte nectedness among a firm's partners inhibit firm's ability to gain access to multiple, redundant information sources. A densely i connected ego network, however, furnishes firm with access to redundant information sou which provide a means for evaluating improving the information received from source. Thus, we should consider the purpo the network under examination, whether it is respect to the industry, the types of relations or the attributes of the network particip before fully understanding the role that struc embeddedness plays in firm performance.

Overall, this study builds on past work structural and relational embeddedness by e ining the simultaneous influence of these fac Our study offers partial support for our conte that these factors are conditioned by each and, therefore, it is more meaningful to con them together rather than independently. M over, the influence of structural and relati embeddedness is contingent on the industry text. Using strategic alliance networks in conductor and steel industries, we illustrate network factors are meaningful in terms of ›rmance, but that there are differential effects ›s environments. We submit that these ›try-dependent findings are the result of vari- .s in what firms require from their strategic ıce networks, and caution future researchers :onsider the interaction of structural and .onal embeddedness, and firms' alliance and ork motives when explaining how networks ›nce firm performance.

‹NOWLEDGEMENTS

ıuthors thank Joel Baum, Robert Bauer, Mar- vans, Robin Kalfleisch, Brian Silverman, and ı Uzzi for helpful comments as well as the : editors of the journal, Ranjay Gulati, Nitin ia, and Aks Zaheer, and two anonymous wers for insights and helpful recommen- ns.

'ERENCES

ı, A. (2000). 'How much do your co-opetitors' ›abilities matter in the face of technological ınge?', *Strategic Management Journal*, Special ue, **21**, pp. 387–404.

er, R. R. (1995). *Directory of American Research d Technology*. Bowker, Providence, NJ.

R. S. (1992). *Structural Holes: The Social Struc- e of Competition*. Harvard University Press, Cam- dge, MA.

R. S. (1998). 'The network structure of social ›ital', paper presented at the Social Network and cial Capital Conference, Duke University, Dur- n, NC.

ıan, J. S. (1988). 'Social capital in the creation human capital', *American Journal of Sociology*, . pp. 95–120.

ıctor, F. and P. Lorange (1988). 'Why should ns cooperate? The strategy and economics basis cooperative ventures'. In F. Contractor and P. range (eds.), *Cooperative Strategies in Inter- :ional Business*. Lexington Books, Lexington, ‹, pp. 3–30.

G. G. and D. W. Beard (1984). 'Dimensions organizational task environments', *Administrative ence Quarterly*, **29**, pp. 52–73.

ın, P. and K. L. Woodard (1994). 'Defining and ating cores and boundaries of social networks', *:ial Networks*, **16**, pp. 267–293.

J. H. (1996). 'Specialized supplier networks as ource of competitive advantage', *Strategic Man- ›ment Journal*, **12**(4), pp. 271–291.

Dyer, J. H. and K. Nobeoka (2000). 'Creating and managing a high performance knowledge sharing network: The case of Toyota', *Strategic Management Journal*, Special Issue, **21**, pp. 345–367.

Garcia-Pont, C. and N. Nohria (1999). 'Global versus local mimetism: How strategic networks get built', paper presented at the *Strategic Management Journal's* Special Issue Conference on Strategic Networks.

Ghemawat, P. (1993). 'Commitment to a process innovation: Nucor, USX, and thin-slab casting', *Journal of Economics and Management Strategy*, **2**(1), pp. 135–161.

Granovetter, M. S. (1973). 'The strength of weak ties', *American Journal of Sociology*, **78**, pp. 1360–1380.

Granovetter, M. S. (1985). 'Economic action and social structure: The problem of embeddedness', *American Journal of Sociology*, **91**, pp. 481–510.

Gulati, R. (1995). 'Social structure and alliance formation: A longitudinal analysis', *Administrative Science Quarterly*, **40**, pp. 619–652.

Gulati, R. (1998). 'Alliances and networks', *Strategic Management Journal*, **19**(4), 293–317.

Gulati, R. and H. Singh (1998). 'The architecture of cooperation: Managing coordination costs and appropriation concerns in strategic alliances', *Administrative Science Quarterly*, **43**, pp. 781–814.

Hagedoorn, J. (1993). 'Understanding the rationale of strategic technology partnering: Interorganizational modes of cooperation and sectoral differences', *Strategic Management Journal*, **14**(5), pp. 371–385.

Hagedoorn, J. and J. Schakenraad (1994). 'The effect of strategic technology alliances on company performance', *Strategic Management Journal*, **15**(4), pp. 291–309.

Hagg, I. and J. Johanson (1983). *Firms in Networks: A New View of Competitive Power*. Business and Social Research Institute, Stockholm.

Hannan, M. and J. Freeman (1989). *Organizational Ecology*. Harvard University Press, Cambridge, MA.

Hite, J. M. and W. S. Hesterly (1999). 'The influence of the firm life cycle on the evolution of entrepreneurial dyadic network ties', paper presented at the *Strategic Management Journal*, Special Issue Conference on Strategic Networks, Northwestern University.

Hosmer, L. T. (1995). 'Trust: The connecting link between organizational theory and philosophical ethics', *Academy of Management Review*, **20**(2), pp. 379–403.

Jarillo, J. C. (1988). 'On strategic networks', *Strategic Management Journal*, **9**(1), pp. 31–41.

Kale, P., H. Singh and H. Perlmutter (2000). 'Learning and protection of proprietary assets in strategic alliances: Building relational-specific capital', *Strategic Management Journal*, Special Issue, **21**, pp. 217–237.

Knoedler, J. T. (1993). 'Market structure, industrial research, and consumers of innovation: Forging backward linkages to research in the turn-of-the-century U.S. steel industry', *Business History Review*, **67**, pp. 98–139.

Knoke, D. (1994). 'Networks of elite structure and decision making'. In S. Wasserman and Galaskiewicz (eds.), *Advances in Social Network Analysis*. Sage, Thousand Oaks, CA, pp. 274–299.

Kogut, B. (1988). 'Joint ventures: Theoretical and empirical perspectives', *Strategic Management Journal*, **9**(4), pp. 319–332.

Krackhardt, D. (1992). 'The strength of strong ties: The importance of philos in organizations'. In N. N. and R. C. Eccles (eds.), *Networks and Organizations: Structure, Form, and Action*. Harvard Business School Press, Boston, MA, pp. 216–239.

Kreps, D. M. (1990). 'Corporate culture and economic theory'. In J. E. Alt and K. A. Shepsle (eds.), *Perspectives on Positive Political Economy*. Cambridge University Press, New York, pp. 90–143.

Lant, T. K., F. J. Milliken and B. Batra (1992). 'The role of managerial learning and interpretation in strategic persistence and reorientation: An empirical exploration', *Strategic Management Journal*, **13**(8), pp. 585–608.

Larson, A. (1992). 'Network dyads in entrepreneurial settings: A study of the governance of exchange processes', *Administrative Science Quarterly*, **37**, pp. 76–104.

Levinthal, D. A. and J. G. March (1981). 'A model of adaptive organizational search', *Journal of Economic Behavior and Organization*, **2**, pp. 207–333.

MaCaulay, S. (1963). 'Non-contractual relations in business', *American Sociological Review*, **28**, pp. 55–70.

Madhavan, R. (1996). 'Strategic flexibility and performance in the global steel industry', dissertation, Katz Graduate School of Business, University of Pittsburgh.

Madhavan, R., B. R. Koka and J. E. Prescott (1998). 'Networks in transition: How industry events (re)shape interfirm relationships', *Strategic Management Journal*, **19**(5), pp. 439–459.

Marascuilo, L. A. and R. C. Serlin (1988). *Statistical Methods for the Social and Behavioral Sciences*. Freeman, New York.

March, J. G. (1991). 'Exploration and exploitation in organizational learning', *Organization Science*, **2**(1), pp. 71–87.

Marsden, P. V. (1988). 'Network data and measurement'. In W. R. Scott (eds.), *Annual Review of Sociology*. Annual Reviews, Palo Alto, CA, pp. 435–463.

Meyer, J. W. and B. Rowan, (1977). 'Institutional organizations: Formal structures as myth and ceremony', *American Journal of Sociology*, **80**, pp. 340–363.

Mowery, D. C. and N. Rosenberg (1989). *Technology and the Pursuit of Economic Growth*. Cambridge University Press, New York.

Nahapiet, J. and S. Ghoshal (1998). 'Social capital, intellectual capital, and the organizational a tage', *Academy of Management Review*, pp. 242–266.

Nohria, N. (1992). 'Is a network perspective a way of studying organizations?'. In N. Nohri R. C. Eccles (eds.), *Networks and Organiz Structure, Form, and Action*. Harvard Bu School Press, Boston, MA, pp. 1–22.

Nohria, N. and C. Garcia-Pont (1991). 'Global st linkages and industry structure', *Strategic M ment Journal*, Summer Special Issue, **12**, pp 124.

Oliver, C. (1991). 'Strategic responses to instit processes', *Academy of Management Review*, pp. 145–179.

Powell, W. W. (1990). 'Neither market nor hier Network forms of organization', *Researc Organizational Behavior*, **12**, pp. 295–336.

Powell, W. W. and P. Brantley (1992). 'Comp cooperation in biotechnology: Learning throug works?'. In N. Nohria. and R. C. Eccles (*Networks and Organizations: Structure, Form Action*. Harvard Business School Press, Boston pp. 366–394.

Powell, W. W., K. W. Koput and L. Smith- (1996). 'Interorganizational collaboration an locus of innovation: Networks of learning in bi nology', *Administrative Science Quarterly* pp. 116–145.

Rowley, T. J. (1997). 'Moving beyond dyadic ti network theory of stakeholder influences', *Ac of Management Review*, **22**(4), pp. 887–910.

Scott, J. (1991). *Social Network Analysis: A Hanc* Sage, Thousand Oaks, CA.

Shannon, C. E. (1957). 'A mathematical theo communication', *Bell System Technical Journc* pp. 379–423.

Uzzi, B. (1996). 'The sources and consequenc embeddedness for the economic performan organizations: The network effects', *American logical Review*, **61**, pp. 674–698.

Uzzi, B. (1997). 'Social structure and competiti interfirm networks: The paradox of embedded *Administrative Science Quarterly*, **42**, pp. 35–

von Hippel, E. (1988). *The Source of Innov* Oxford University Press, New York.

Walker, G., B. Kogut and W. Shan (1997). 'S capital, structural holes and the formation of i try networks', *Organization Science*, pp. 109–125.

Wasserman, S. and K. Faust (1994). *Social Ne Analysis: Methods and Applications*. Camb University Press, New York.

Williamson, O. (1985). *The Economic Institutio Capitalism: Firms, Markets, Relational Contra* Free Press, New York.