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

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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.

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hat long ago, the notion that firms improve
1 have been viewed as an oxymoronic
2. Currently in strategic alliances research, however, cooperating with competitors is consid-
3er, not only are particular dyadic strategic
4al strategies valuable, but the pattern of
5al alliances in an industry is also meaning-
6ful in terms of competitive advantage (Dyer,
7Gulati, 1998; Jarillo, 1988; Madhavan,
8and Prescott, 1998). Because a strategic
9 network leads to asymmetric access to
10nes across the industry, it can facilitate
11e of a firm’s behavior and performance

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
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 beneficial 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 related to firm performance. This increases our understanding of how firms should be embedded in all networks and contributes to resolving the tension surrounding the different forms of social capital. Second, we provide empirical support for the importance of social capital and the form of its network influence on performance.

The steel and semiconductor industries present an opportunity to empirically examine how work embeddedness influences performance. Manufacturing firms in both of these industries utilize bilateral and multilateral alliances with firms in order to execute components of their product and production activities. The research used for this examination involves separate alliances for each industry. These networks consist primarily of horizontal alliances, which allow for some of the effects. Power-related tie between partners can play an important role among several overlying-dependent subnetworks. An alliance is defined ‘as any voluntarily initiated cooperative agreement between firms that involves exchange, sharing co-development, and it can include contributions by partners of capital, technology, or firm-specific assets,’ including information and know (Gulati and Singh, 1998). More specifically, strategic alliances comprising the networks in cohesive/intense ties involving substantial investments such as equity ties, manufacturing ventures, and joint R&D projects, and w linkages, such as marketing and licensing agreements and standards, and training arrangements. In the next section, we discuss the performance effects of relational and structural embeddedness as described in the literature and then generate hypotheses related to a discussion of their interaction effects as well as the role played by environmental context.

RELATIONAL EMBEDDEDNESS

Granovetter (1973: 1361) defines tie strength as a function of the amount of time.
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ontal intensity, the intimacy (mutual confiding), reciprocal services which characterize the For the purposes of examining interorganiz-

tional networks characterized by horizontal ties, we measure tie strength by the frequency of

eraction between partners and their level of commitment to the relationship. Strong ties,
such as equity arrangements, manufacturing joint ventures, and joint R&D projects, are ler and deeper in terms of investment and action

than marketing joint ventures and technologic licensing, which require less coordination or standing of partners' organizations (Powell,

314). The other dimensions—the emotionality and intimacy—are pertinent for the indi-

level relationships central in Granovetter’s work, but are not as applicable to the

horizontal alliances comprising this study. In literature, strong ties are shown to provide

izations with two primary advantages. First, ties are associated with the exchange of

quality information and tacit knowledge. Uzzi observed in his study of the New York real estate industry that firms participating in strong
ties are able to exchange fine-grained knowledge.

development of strong ties, interfirm partners about each other’s organization, become more
den on one another and develop relational (Larson, 1992). Based on a deeper under-

ing of a partner’s operations, tacit knowledge are readily transferred across organizational

aries, which are blurred by close contact (and Johanson, 1983). Second, strong ties serve as part of the social

mechanism, which governs partnership

ers. Firms enter strategic alliances with

tors to gain access to external resources, risks and cost, or pool complementary skills

doom, 1993; Kogut, 1988; Hagg and Johan-

983). However, interorganizational alliances with potential hazards. Because interfirm

ations do not possess the control and nation mechanisms governing hierarchies or

ts, participating firms are susceptible to the

associated with opportunism (Williamson, 1985). Moreover, formal contracts are often ineffectual governance devices, because they cannot

over all contingencies and may even under

collaborative efforts (MaCaulay, 1963).

on (1992) shows that strong ties incrementally

and, in turn enhance, trust, mutual gain,
city, and a long-term perspective. Conse-

quently, 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 governance mechanisms supplied via the dense network, the firm will gain much less from strong ties if dense network than when its partners are sparsely connected. The structure itself has pro-organizational norms to guide actions. As a result, firms often coordinate through the use of a relatively weak network (Burt, 1998). This is partly because weak ties are more likely to provide unique and valuable information, while strong ties are more likely to provide redundant information.

Hypothesis 1: The positive relationship between strong ties and firm performance is greater in sparse ego networks than in dense networks.

EMBEDDEDNESS IN DIFFERENT ENVIRONMENTAL CONTEXTS

The debate surrounding social capital is centric to understanding how a firm should be structured and embedded in its industry's web of strategic alliances. Social capital theorists agree that actors who are better connected to the network have a competitive advantage over poorly connected actors. However, there is much disagreement regarding what it means to be "better connected" (Burt, 1998). Coleman's (1988) closure concept, which states that actors are better connected as they become more interdependent, is in complete contrast to Burt's (1998) closure concept. Burt (1998) suggests a complementarity 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 ambistem 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 capital provide different benefits, which are 1 for different strategic purposes. We will these distinct benefits and propose cons under which firms will be ‘better connectia the hole and closure forms of social capi- mentioned above in the discussion of ren- governance, Coleman (1988) argues that one benefits of dense ties among a group of (closed network) is collective social cap which promotes shared behavioral norms ley, 1997) and cooperation (Walker et al., 1. Competitive firms within a dense clique strategic alliances can rely on its partners to cese to the group’s cooperative norms. On ther hand, firms occupying many structural —the positions between other actors who x directly linked—enjoy efficiency and conbenefits. Ties to multiple actors, who are ted to one another, provide redundant nation (Granovetter, 1973; Burt, 1992). er, a firm occupying many structural holes redant ties and economizes on the er of ties required to access unique inform Further, firms situated in structural holes arded control benefits because they act as ediators between disconnected partners, ely on the firm to facilitate exchange flows the network. Thus, dense networks are eous for developing trust and cooperation g collective monitoring and sanctioning, but redant information from multiresources. In contrast, a sparse network provides ith the ability to efficiently obtain and ination (resources), but the structure not generate a governance mechanism to e opportunism. A firm occupying many oral holes will have an advantage over itsitors who rely on it to send and receive ation and resources in the network of strailliances. Thus, to understand how firms can competitive advantages through structural idness, 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 Noeoka, 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 Noeoka (2000) report that core groups of five to seven suppliers sharing common operations (jishukan 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 exploration and exploitation 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. Nahapet 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, innovation is suppressed (Coleman, 1988). Burt (1992) suggests that connections to a group of partners will connected to one another provide redundant information and limit the firm’s access to diverse perspectives and sectors of the environment. Fact, Burt’s (1992) structural hole advantage stresses that the optimal network position gaining access to unique information occurs when a firm’s partners are not connected to one another or similar others. A firm gains unique information and perspectives from each of its partners occupying structural holes. Thus, in uncertain environments demanding relatively high innovation, low-density network structures are preferred.

Hypothesis 2: For firms in environments demanding relatively high investment in exploration, the density of ties among a set of partners is negatively related to its performance.

Although firms that invest heavily in exploiting activities are likely to internalize the innovation/technology, they still utilize external ties for the purpose of accessing knowledge. They will help refine their technologies at lower operating costs. Mowery and Rosenberg (1997) argue that internal activities and interorganizational ties are not substitutes, but rather important and necessary complements. ‘In a capability is indispensable in evaluating resources done outside, while external collaboration vides access to news and resources that can’t be generated internally’ (Powell, Koput, and S. Doer, 1996: 119). ‘External linkages are both a means of gaining fast access to knowledge and resources that cannot be secured internally and a test of internal expertise and learning abilities’ (Powell and Brantley, 1992: 371).

Moreover, there is evidence that firms investing heavily in exploitation form external ties to complement and evaluate internally generated knowledge. Dyer and Noeoka (2000) found that Toyota’s suppliers participate in voluntary teams in which they review other suppliers’ actions and provide advice on cutting costs. larly, von Hippel (1998) illustrates that engaged from rival firms in the steel industry establish informal linkages across which they exchange information on how to reduce production...
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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 its 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 data for the period 1990–94 (a period not cover the CMP data base), we consulted the Dow Strategic Partnership Report, an extensive base and analysis of relationships among tech firms from 1990 to 1996. Domicity’s which contained information on 1754 ties also used to verify the CMP data because 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. Fur more, the two independent reports were for gaining a general estimate of the reli of the data collection method: There was percent consistency in the relationships reg by these two sources for the period of covered by both data sets. In addition to data sources, we consulted two industry anno. Each expert was given a report on the semi conductor relationships captured in the data set asked to identify errors—missing relation reported relations that did not actually between firms.

**Steel network**

Relational data for the steel industry were collected from the Dow Jones News Retrieval System, the Globe and Mail data base and trade publications, such as Metal Bulletin, a global news journal for the iron, steel, and ferrous metal industries. The data collection technique for the steel industry paralleled procedure used for the semiconductor industry and spanned the same time period (January 1990 to June 30, 1997). Additional relational data, and verification of the data gathered secondary sources, were gained from a pre-network study of the steel industry. Madhavan (1996) data base consisted of relation formed among steel-producing firms from 1990 and 1993. These data represented 3000 relation from the Dow Jones News Retrieval System which were transformed into a network of strategic alliances.

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

use there are different types of strategic alliances, researchers must decide how to measure tie type. Contractor and Lorange (1988) constructed an ordinal scale, which assigns weights to each alliance type based on the intensity/strength of the linkage. This treatment is appropriate for the purpose of identifying and describing the structural elements of the triad, such as mapping strategic groups, competition, and Garcia-Pont, 1991). To understand behaviors and performance of firms in the network, however, it is important to perform a fine-grained analysis of alliance data. Giving the highest weight for multiple alliances between a pair of actors assumes that strong and weak ties are different in degree only. Therefore, the types of behaviors associated with a strong tie are the same as a weak tie, only more so. Several researchers, however, argue that the nature of weak and strong ties is different in kind as well as degree (Granovetter, 1985; chardt, 1992; Uzzi, 1996). Strong ties do not replace weak ties—they serve different purposes. A different set of alliance behaviors.

by treating strong and weak ties as separate constructs rather than degrees of one another, we get a richness in the data, which past researchers deem important in understanding network effects and firm behaviors. We collected alliance data on several types of strategic ties based on categories adapted from the scheme of Contractor and Lorange’s (1988) scheme. While treating the categories as an ordinal scale, we classify these alliance types into two groups: strong and weak ties. There is a natural demarcation among these ties based on the resources invested in the alliance. In addition to a substantially higher level of resource commitment, alliance types in the strong tie category are ‘up front’ resources and significantly more important interactions. Partners must invest in the alliance before realizing any benefit and maintain interactions to yield those benefits. The alliances under the weak tie category require a significantly smaller resource commitment from partners, 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.

![Image](image-url)

**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 by the total possible number of ties among its partners if each partner were tied to every other partner.

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

Exploitation/exploration

As mentioned above, firms facing a high degree of environmental uncertainty will need to explore more in exploring new opportunities and diversions than firms facing stable environments in which they can allocate more resources to existing technologies. Thus, following La et al.’s, (1992) approach to comparing firms’ different degrees of environmental turbulence, we examine firms (and their networks) in industries—steel and semiconductor—exhibiting different degrees of environmental uncertainty in order to investigate embeddedness effects in contexts requiring different mixes of exploitative and explorative. These industries differ in terms of the environmental complexity, predictability, and quiescence of change (Dess and Beard, 1984), which translate into different strategic investments.

First, over a 10-year period ending in 1985, the variation on sales, which captures the dictability dimension of the environment (Dess and Beard, 1984, Lant et al., 1992), was seen to be larger in the semiconductor industry than in the more stable steel industry. The steel industry, which epitomized the staid, typical mature industry, was characterized by relatively fixed product/market mix, few product innovations, and few new entrants. These factors contributed to relatively infrequent changes in the environment. The only dramatic environmental change punctuating the stable steel industry was the introduction of the compact strip production process employed in mills (Ghemawat, 1993). This environment shock reduced costs, especially on custom orders involving relatively smaller quantities than...
in the integrated steel production process.

contrast, owing to rapid technological change product obsolescence, as well as the continual emergence of new markets, the semiconductor industry has been characterized as a volatile environment (Hannan and Freeman, 1989). The addition of technologies, including converging technologies, translated into relatively uncertain changing markets, which demanded that firms liberate their competitive advantages to fit changes.

The Directory of American Research and Technology (Bowker, 1995), which describes research development activities of American corporations, was useful for illustrating this difference between the steel and semiconductor industries. A set of 40 steel and 28 semiconductor firms listed in the networks was identified in the directory (see Table 1). The percentage of engineers with Ph.D. degrees on staff was similar in the semiconductor and steel industries: 14.8 percent and 12.9 percent, respectively. However, the average number of different Ph.D. specialties in the semiconductor, five—chemical, electrical, mechanical, systems engineering, and physics—twice that of the steel industry—chemical, mechanical, and metallurgy. Also, the number of different Ph.D. specialties in the semiconductor industry was 14, but only 6 for firms in the sample. This comparison provides evidence, albeit on a subset of U.S. firms, that steel and semiconductor firms operate on different levels of environmental complexity.

1. Differences in range and type of research activities

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<th>Semiconductor</th>
<th>Steel</th>
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<tr>
<td>Ph.D.s on R&amp;D staff</td>
<td>14.8</td>
<td>12.9</td>
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<tr>
<td>% of Ph.D. specialties on staff</td>
<td>5</td>
<td>2.5</td>
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<td>6</td>
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</tr>
</tbody>
</table>

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. mini-mills, 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 of relational embeddedness—strong (STRONG TIES) and weak (WEAK TIES) ties—and structural embeddedness—density (DENSITY)—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 to performance ($p < 0.05$). This point provides in support for Hypothesis 5, which is directly in Table 5.

In Model II, we examine the influence of structural embeddedness factor on firm performance, but find support for neither Burt’s (hole or Coleman’s (1988) closure argument. Although DENSITY is negatively related to performance, the result is not statistically significant. Model II displays the OLS regression involving density (interconnectedness) and Interconnectedness does not have any significant effect on ROA.

In order to determine whether relational embeddedness is moderated by structural embeddedness, we examine DENSITY, STRONG TIES, WEAK TIES together in Model III (see Table 4). In addition, we are also interested in the potential differential effects due to industry, so the dummy variable for industry was also included. Thus, we examine the main effects due to tie type network structure as well as industry. Although Model I STRONG TIES is significantly related to ROA, in Model III the direction is still negative but it is no longer significant. Conversely, WEAK TIES is still significant in Model III and has a positive impact on ROA. The main effect of industry is still negative in Model (as it is in both Models I and II), but is a significant finding. In examining Hypothesis 1, namely that the interaction of the governance mechanisms—relational and structural embeddedness—will reduce performance, we

<table>
<thead>
<tr>
<th>Table 2. Total industry descriptive statistics</th>
<th>Steel</th>
<th>Semiconductor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$N$</td>
<td>Min.</td>
</tr>
<tr>
<td># of ties</td>
<td>138</td>
<td>24</td>
</tr>
<tr>
<td>DENSITY</td>
<td>77</td>
<td>1</td>
</tr>
<tr>
<td>Net income (millions of $)</td>
<td>41 7510.0</td>
<td>−350.7</td>
</tr>
<tr>
<td>ROA</td>
<td>58</td>
<td>0.22</td>
</tr>
<tr>
<td>SUM_STRG</td>
<td>138</td>
<td>19</td>
</tr>
<tr>
<td>(Total # strong ties)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUM_WEK</td>
<td>138</td>
<td>7</td>
</tr>
<tr>
<td>(Total # weak ties)</td>
<td></td>
<td></td>
</tr>
<tr>
<td># partners strong</td>
<td>138</td>
<td>12</td>
</tr>
<tr>
<td># partners weak</td>
<td>138</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>LNASSETS</td>
<td>COUNTRY</td>
</tr>
<tr>
<td>------------------</td>
<td>----------</td>
<td>---------</td>
</tr>
<tr>
<td>LNASSETS</td>
<td>-0.259*</td>
<td></td>
</tr>
<tr>
<td>COUNTRY</td>
<td>0.050</td>
<td>-0.083</td>
</tr>
<tr>
<td>DENSITY</td>
<td>0.100</td>
<td>-0.064</td>
</tr>
<tr>
<td>INDUSTRY</td>
<td>0.125</td>
<td>-0.015</td>
</tr>
<tr>
<td>STRONG</td>
<td>-0.022</td>
<td>-0.017</td>
</tr>
<tr>
<td>WEAK</td>
<td>0.118</td>
<td>-0.080</td>
</tr>
<tr>
<td>DEN*STRG</td>
<td>0.049</td>
<td>-0.039</td>
</tr>
<tr>
<td>IND*STRG</td>
<td>0.044</td>
<td>0.034</td>
</tr>
<tr>
<td>DEN*IND</td>
<td>0.117</td>
<td>-0.067</td>
</tr>
</tbody>
</table>

**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

<table>
<thead>
<tr>
<th>Variable</th>
<th>Relational embeddedness</th>
<th>Structural embeddedness</th>
<th>Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>0.0148</td>
<td>-0.0581</td>
<td>0.0022</td>
</tr>
<tr>
<td>LN ASSETS</td>
<td>0.0002</td>
<td>0.0057*</td>
<td>0.0031</td>
</tr>
<tr>
<td>COUNTRY</td>
<td>0.0015</td>
<td>0.0075*</td>
<td>0.0008</td>
</tr>
<tr>
<td>DENSITY</td>
<td>-0.0341</td>
<td>-0.0124</td>
<td>-0.0798**</td>
</tr>
<tr>
<td>INDUSTRY</td>
<td>0.0206</td>
<td>-0.0124</td>
<td>-0.0798**</td>
</tr>
<tr>
<td>STRONG TIES</td>
<td>-0.0059**</td>
<td>-0.0025</td>
<td></td>
</tr>
<tr>
<td>WEAK TIES</td>
<td>0.0108**</td>
<td>0.0073**</td>
<td></td>
</tr>
<tr>
<td>DENSITY*STRONG</td>
<td></td>
<td>0.0124*</td>
<td></td>
</tr>
<tr>
<td>INDUSTRY*STRONG</td>
<td>0.0094**</td>
<td>0.0141***</td>
<td></td>
</tr>
<tr>
<td>INDUSTRY<em>STRONG</em>DENSITY</td>
<td>0.0239</td>
<td>0.0999*</td>
<td></td>
</tr>
<tr>
<td>DENSITY*INDUSTRY</td>
<td></td>
<td>0.0007</td>
<td></td>
</tr>
<tr>
<td>DENSITY*WEAK</td>
<td>-0.0035*</td>
<td>-0.0479</td>
<td></td>
</tr>
<tr>
<td>INDUSTRY*WEAK</td>
<td></td>
<td>-0.0017</td>
<td></td>
</tr>
<tr>
<td>INDUSTRY*WEAK</td>
<td></td>
<td>0.0009</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>120</td>
<td>98*</td>
<td>98</td>
</tr>
<tr>
<td>R² (adjusted)</td>
<td>0.3550</td>
<td>0.3500</td>
<td>0.454</td>
</tr>
</tbody>
</table>

*α < 0.1; **α < 0.05; ***α < 0.01

The inclusion of interaction partners density (DENSITY) reduces the degrees of freedom from 120 to 98. The organizations who were connected to isolates had a density measure which was undefined, and were dropped from the analysis.

Table 5. Exploitation/exploitation environments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Beta coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Steel (Model IV exploitation)</td>
</tr>
<tr>
<td>(Constant)</td>
<td>-0.0330</td>
</tr>
<tr>
<td>LN ASSETS</td>
<td>0.0011</td>
</tr>
<tr>
<td>COUNTRY</td>
<td>-0.0024</td>
</tr>
<tr>
<td>DENSITY</td>
<td>0.0901**</td>
</tr>
<tr>
<td>STRONG TIES</td>
<td>0.0119***</td>
</tr>
<tr>
<td>WEAK TIES</td>
<td>0.0057</td>
</tr>
<tr>
<td>DENSITY*STRONG</td>
<td>-0.0168*</td>
</tr>
<tr>
<td>DENSITY*WEAK</td>
<td>-0.0491</td>
</tr>
<tr>
<td>R² (adjusted)</td>
<td>0.4360</td>
</tr>
</tbody>
</table>

*α < 0.1; **α < 0.05; ***α < 0.01

That exploitation/exploitation (DENSITY*INDUSTRY) is not directly tested in Model III. How the interaction effect of these two variables is significant (p < 0.10), which implies that formance is more positively affected by density in the steel industry than in the semiconductor industry. In order to directly test Hypotheses 3, Models IV and V were created (Table 5) and are discussed below.

Hypothesis 5—INDUSTRY*STRONG should have a positive effect—is not directly tested in Model III. However, we find that when compared with the exploration environment, the exploitation context does have a significantly greater positive effect on ROA owing to strong ties. To directly test Hypotheses 5 and 6 we must again examine Models IV and V. The interaction of industry and weak ties (INDUSTRY*WEAK) is not significant and does not support Hypothesis 4. However, to directly test for this hypothesis we can examine Models IV and V.

Directly testing exploitation and exploration

To further examine the actual difference 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 effects of density, and strong and weak ties on performance in the steel industry. Similarly, Model V (see Table 5) examines the effects of density, and strong and weak ties on performance in the semiconductor industry. These results suggest that interconnectedness is positively related to performance for the purposes of exploitation. This supports Hypothesis 2. As in Model I, the results in Model IV support the contention in Hypothesis 5 that strong ties are positively related to performance in environments suffering a relatively high degree of exploitation. In addition, the results from Model IV support Hypothesis 1, because the interaction involving density and strong ties (DENSITY*STRONG) is significant at 0.10.

Table 5, Model V illustrates the regression specific to the exploration setting (iconductor industry). Hypothesis 4 is supported (p < 0.05)—the number of weak ties a has with its strategic alliance partners is positively related to firm performance in environments demanding relatively high levels of exploitation. The significant and negative relationship between the density and strong tie interaction (DENSITY*STRONG) supports Hypothesis 2—strong ties in the network are negatively related to performance in this environmental context. However, the data do not support Hypothesis 6, which states that strong ties are negatively related to firm performance in the exploration setting.

**Discussion**

This study is useful for identifying sources of competitive advantage in interorganizational networks by reconciling some of the competing views surrounding how relational and structural embeddedness factors influence performance. We consider the conditions under which strong and weak ties (relational embeddedness), and closed and sparse networks (structural embeddedness) are sources of competitive 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 noncausal main effect, there is support for our hypothesis postulating that density is beneficial in the exploitation context. However, the results do allow us to comment beyond our theoretical framework regarding the negative role density plays in the exploration setting (hole argument). In exploitation model (steel industry), the finding suggest that dense ties among a firm’s strategic partners could be a source of competitive advantage (closure argument).

Like tie intensity, the influence of connectedness among a firm’s alliance partners can only be appreciated with reference to industry context. The hole argument states density has a negative effect on performance because the probability that a firm will have opportunities to access and broker unique information diminishes as interconnectedness increases (Burt, 1998: 13). However, the results in study do not support this logic. Again, it is in the industry context that determines whether connectedness influences performance. Depending on the extent to which a firm is engaged in exploitation or exploration, its purpose accessing its network will change. As a result, how structural embeddedness factors into firm performance will also change. Interconnectedness among a firm’s partners inhibit the firm’s ability to gain access to multiple, redundant information sources. A densely interconnected ego network, however, furnishes a firm with access to redundant information sources which provide a means for evaluating and improving the information received from multiple sources. Thus, we should consider the purpose of the network under examination, whether it is focused on the industry, the types of relations or the attributes of the network participants before fully understanding the role that structural embeddedness plays in firm performance.

Overall, this study builds on past work on structural and relational embeddedness by examining the simultaneous influence of these factors. Our study offers partial support for our contention that these factors are conditioned by each other and, therefore, it is more meaningful to consider them together rather than independently. Moreover, the influence of structural and relational embeddedness is contingent on the industry context. Using strategic alliance networks in
conductor and steel industries, we illustrate network factors are meaningful in terms of romance, but that there are differential effects in environments. We submit that these industry-dependent findings are the result of variability in what firms require from their strategic networks, and caution future researchers on the interaction of structural and non-structural embeddedness, and firms’ alliance and vertical motives when explaining how networks shape firm performance.

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