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NETWORK STRUCTURE AND INNOVATION: THE LEVERAGING OF A DUAL NETWORK AS A DISTINCTIVE RELATIONAL CAPABILITY

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This paper employs comparative longitudinal case study research to investigate why and how strong dyadic interfirm ties and two alternative network architectures (a 'strong ties network' and a 'dual network') impact the innovative capability of the lead firm in an alliance network. I answer these intrinsically cross-level research questions by examining how three design-intensive furnishings manufacturers managed their networks of joint-design alliances with consulting industrial design firms over more than 30 years. Initially, in order to explore the sample lead firms' alliance behavior, I advance an operationalization of interorganizational tie strength. Next, I unveil the strengths of strong ties and the weaknesses of a strong ties network. Finally, I show that the ability to integrate a large periphery of heterogeneous weak ties and a core of strong ties is a distinctive lead firm's relational capability, one that provides fertile ground for leading firms in knowledge-intensive alliance networks to gain competitive advantages whose sustainability is primarily based on the dynamic innovative capability resulting from leveraging a dual network architecture. Copyright © 2007 John Wiley & Sons, Ltd.

INTRODUCTION

The growing importance of alliance networks as competitive units (Gimeno, 2004; Nohria and Garcia-Pont, 1991) and the need to develop a deeper appreciation of networks' dynamics (Brass *et al.*, 2004; Madhavan, Koka, and Prescott, 1998) make it urgent that we expand our understanding of how firms that play the role of the 'strategic center' (Lorenzoni and Baden Fuller, 1995) in interfirm networks (i.e., lead firms) manage their web of partners over time. Building on previous research, I argue that, to be able to manage their networks strategically, lead firms require a distinctive set of

relational capabilities. The primary objective of this study is to shed light on a single relational capability, namely the lead firm's capability to sustain its innovativeness by creating and managing the overall architecture of its network over time. This demands a deeper analysis of the relationships between network structure and firm-level innovation.

Despite some research on the relationships between network structure and effectiveness in health services (Provan and Milward, 1995), and between network structure and various organizational outcomes in SME networks (Human and Provan, 1997), little is known about whether, why, and how different network architectures exert asymmetric impacts on the innovative capability of the network's leading actor. Several contributions (Uzzi, 1997; Rowley, Behrens, and Krackhardt, 2000) have yielded valuable advances by drawing on

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(and adding to) social network theory. In particular, the strength of (interorganizational) ties has been employed in *cross-level research* aimed at analyzing the structure of interfirm networks and its impact on firm-level innovation (e.g., McEvily and Zaheer, 1999).

However, the operationalization of interorganizational tie strength awaits further contributions. Moreover, at the network level of analysis, and focusing specifically on the intersection with the firm level, both the weaknesses of a network architecture in which strong ties predominate (i.e., a 'strong ties network') and the strengths of a 'dual network'—that is, a network architecture wherein a small core of strong ties is integrated with a larger periphery of weak ties—need to be uncovered. This, in turn, takes us back to some critical questions at the dyad level of analysis, specifically at the intersection with the firm level. Here, while the strength of weak ties has often been emphasized, the strength of strong ties and the processes through which strong ties support firm-level innovation deserve further research.

My purpose in this paper is to attempt to fill the above gaps by investigating the relational capability of three lead firms to sustain their innovation over time by leveraging the structure of their alliance networks. To this end, I apply comparative longitudinal case study research to answer two major and strictly linked research questions that cut across different levels of analysis while sharing the same firm-level outcome variable, namely the lead firm's innovative capability. My research questions are: 'Why and how do strong dyadic ties impact the lead firm's innovative capability over time?'; and 'Why and how do alternative network structures (i.e., a strong ties network and a dual network) impact the lead firm's innovative capability over time?'

As a result, I offer the following contributions. First, I advance an operationalization of the strength of interorganizational relationships that builds on Granovetter's (1973) original definition of tie strength. Second, I discuss the strengths of strong ties, the weaknesses of a strong ties network, and the processes through which strong ties and a strong ties network exert their influence over time on the lead firm's capability to innovate. Finally, I explain why and how a dual network architecture impacts positively the innovative capability of its leading actor, and I argue that lead firms can sustain their innovation over

time by relying on dual networks. By doing so, I contribute to our knowledge of the relational capabilities that lead firms leverage to build and sustain competitive advantages, in an attempt to offer valuable insights for academics and practitioners alike.

The paper is organized as follows. After reviewing the relevant literature and addressing major levels issues and the operationalization of tie strength, I set out methods and results of a comparative longitudinal study of how three sample furnishings manufacturers managed their large networks of dyadic joint-design alliances over an investigation period of more than 30 years. The final sections contain discussion and conclusion, together with limitations, implications for managers, and avenues for further research.

THEORETICAL BACKGROUND

Relational capabilities for alliance network management

For the purposes of this study, alliances¹ are inter-firm collaborative relationships directed to the generation of relational rents (Dyer and Singh, 1998). They consist of joint value-creation processes (Zajac and Olsen, 1993) which develop over time (Ring and Van de Ven, 1994) and are embedded in their surrounding social context (Gulati, 1998). Recent contributions describe alliance networks as strategic assets (i.e., 'strategic networks': Gulati, Nohria, and Zaheer, 2000) that lead firms leverage to generate differential returns for both participating firms and the network as a whole (Baum, Calabrese, and Silverman, 2000; Dyer and Hatch, 2006; Gomes-Casseres, 1996). However, network management requires a deeper understanding of its inherent challenges (Das and Teng, 2002; Jones, Hesterly, and Borgatti, 1997; Sobrero and Roberts, 2001). Specifically, the development and leveraging of a distinctive set of relational capabilities is crucial for the lead firm to be able to tap into the strategic potential of its alliance web.

The debate on relational capabilities is still in its infancy. In an influential paper, Powell, Koput,

¹ I use henceforth the expressions (strategic) alliances and (interorganizational) relationships or ties interchangeably to refer to the definition of alliances advanced here. The (interfirm) networks I refer to in this study are alliance networks.

and Smith-Doerr (1996) sketched out the organizational capability to manage 'networks of learning' as consisting of routines specifically devoted to interorganizational knowledge transfer. More recently, Dyer and Nobeoka (2000) have examined in detail the knowledge-sharing routines developed by Toyota to promote superior learning in its supplier network. Along a similar vein, Lorenzoni and Lipparini (1999) have argued that the ability to integrate knowledge that resides both inside and outside a firm's boundaries is a distinctive capability for transactionally intensive firms. Interestingly, these contributions share a knowledge-based perspective according to which alliance networks are created and managed by lead firms which leverage network-wide knowledge access, transfer, and creation to generate competitive advantages based on superior innovation. Building on these insights, I investigate how three lead firms shaped the *structure* of their knowledge-intensive networks over time to sustain their innovative capability.

Innovation, network structure, and strength of ties

The positive impact of interfirm networks on innovation has been traced back to the potential of interorganizational collaboration to facilitate knowledge sharing and interactive learning processes among participating firms (Inkpen and Tsang, 2005; Powell *et al.*, 1996). This potential, in turn, is claimed to be strongly dependent on the overall network structure (e.g., Ahuja, 2000a; Zaheer and Bell, 2005). Essential to this reasoning is the notion of 'bridge' (Harary, Norman, and Cartwright, 1965). According to Burt's (1992) principles for network building, a focal firm should maximize the proportion of bridges (i.e., nonredundant contacts) to total contacts in the network. This has relevant implications in the case of a lead firm and its first-order alliance network: in order to increase its potential to generate innovation, the lead firm should focus on the *diversity* of its direct contacts, whose *number* is relevant to the extent that it increases the probability of network diversity.

The above reasoning has considerable connections with strength-of-ties arguments. Tie strength researchers typically classify both interpersonal and interorganizational relationships as being either strong or weak. As Granovetter (1973) pointed

out, strong ties (i.e., long-lasting, repeated, and socially dense relationships) cannot be bridges. Conversely, although weak ties are not automatically bridges, bridges tend to be weak ties (see also Friedkin, 1980), which leads to 'the strength of weak ties' (Granovetter, 1973). In the domain of interorganizational relationships, the strength of weak ties results from the potential of weak ties to foster and speed up innovation by connecting a focal firm to otherwise difficult-to-reach knowledge areas (Rogers, 2003). By adding weak ties to its network, a lead firm is likely to add nonredundant contacts and hence expand network diversity (Burt, 1992), thereby increasing its performance (Rowley *et al.*, 2000).

Other scholars have claimed the strength of strong ties (Krackhardt, 1992; Nelson, 1989). Strong interfirm ties are valuable competitive tools, especially for lead firms faced with uncertainty (Keister, 1999). Indeed, they can offer steady flows of new ideas, technological innovations, and operational support. Several studies in the domain of interfirm alliances have highlighted how strong ties encourage reciprocity, a long-term perspective, and joint problem-solving arrangements (Larson, 1992; Uzzi, 1997). Also, strong ties have been found to stimulate knowledge transfer and protection in interorganizational settings (Dyer and Nobeoka, 2000; Kale, Singh, and Perlmutter, 2000) and promote adaptation to environmental changes (Kraatz, 1998).

However, the benefits that strong ties bring to the innovation processes deserve further systematic research. Moreover, moving upward from the dyad level to the network level of analysis, Uzzi's (1997) notion of 'overembeddedness' suggests that strategic networks composed mostly of strong ties may threaten innovation, rather than enhancing it. Finally, the distinctive and somewhat complementary roles of weak and strong ties lead to the idea that integrating strong and weak ties within the same alliance network would guarantee superior firm-level innovation due to the coexisting opportunities for *exploitation* and *exploration*, and would therefore represent a distinctive relational capability for the leading actor in the network. Following this route, at the outset of this research I advanced the argument that network architectures that differ in tie strength exert a different impact on the innovative capability of the lead firm in an alliance network.

LEVELS ISSUES IN NETWORK RESEARCH

The present study adopts a theoretical stance informed by social network research. Levels-of-analysis issues are especially relevant for network researchers, whose research questions usually lie at the intersection between different levels. For the purposes of this paper, two such issues are worth addressing.

First, in social network research ‘micro and macro can be very similar theoretically and methodologically’ (Borgatti and Foster, 2003: 1001), and thus theories and constructs initially developed for the study of interpersonal relationships are frequently applied to the analysis of interorganizational linkages. In addition, network researchers in the field of interfirm relationships have commonly resorted to dyadic constructs and data to explore firm-, dyad-, network-, and mixed-level research questions (Borgatti and Foster, 2003). Thus, after its birth and early use in the domain of interpersonal relationships (Granovetter, 1973), the strength of ties has been recently employed as a major (dyad-level) theoretical construct to analyze interorganizational relationships, in particular the structure of interfirm networks and its impact on learning and innovation, often at the level of single firms (e.g., McEvily and Zaheer, 1999). This has two major implications. First, we need to tackle the operationalization of tie strength with specific reference to the interorganizational level—a point I will resume later in this paper. Second, the above tie-strength research in interorganizational settings is intrinsically cross-level, as it tries to draw causal models of the relationships between constructs across different levels of analysis (Rousseau, 1985), usually with the aim of deepening the understanding of the impact of network- and dyad-level variables on firm-level innovation. This is also the case with the present study, which acknowledges its cross-level nature and therefore ranges over and across three levels of analysis: the lead firm level, the dyad level, and the network level.

A second levels issue in network research concerns the linkages between interpersonal and interorganizational relationships. In fact, since interorganizational relationships are managed by individual boundary spanners who interact on behalf of their organizations across the organizations’ boundaries, *micro* behaviors at the interpersonal

level generate *macro* outcomes at the interorganizational level (e.g., Zaheer, McEvily, and Perrone, 1998). Accordingly, I argue that social contents and trust existing in the relationships between individual participants in interfirm alliances impact the relationships between their organizations, and specifically increase the strength of interorganizational relationships.² Consequently, this paper emphasizes the interpersonal side of interfirm alliances and takes it into account in operationalizing tie strength at the interorganizational level.

OPERATIONALIZING TIE STRENGTH

The strength of ties is a primary construct in investigating this study’s research questions. At first, Granovetter (1973: 1361) framed tie strength at the interpersonal level of analysis as a continuous (dependent) variable resulting from a linear combination of a set of (independent) variables expressing multiple dimensions of partners’ behavior in the relationship. Along a continuum of tie strength, the definition advanced by Granovetter would allow us to distinguish between strong(er) and weak(er) ties on the basis of how partners behave in the relationships. Since then, the strength of ties has been employed extensively to analyze social structure and action at both interpersonal and interorganizational levels (Granovetter, 1982; Rogers, 2003), while little effort has been made to distinguish between interpersonal and interorganizational tie strength. From a substantive standpoint, extant strength-of-ties literature on both levels provide considerable evidence that partners involved in dyads holding the same kind of relationship (strong or weak) behave homogeneously. Conversely, the behavior of partners in strong ties has been found to be different from that of partners in weak ties.

From a methodological perspective, the richness of Granovetter’s original proposal has largely been neglected. To begin with, in his classic study, Granovetter (1974) himself operationalized strong interpersonal ties as those who interacted at least twice per week. Analogously, the frequency of interaction has been adopted in subsequent works

² This linkage also operates the other way round. Indeed, interorganizational relationships imbued with trust and reciprocity will induce and/or strengthen social contents among participating individuals, thereby increasing the strength of interpersonal relationships between individual boundary spanners.

as a proxy for the strength of interorganizational as well as interpersonal relationships (McEvily and Zaheer, 1999; Nelson, 1989), with the cut-off value being modified according to the nature and content of the relationships. However, a single variable may not fully capture all the relevant dimensions of partners' behavior, and any cut-off value set to separate strong from weak ties may in fact easily turn out to be arbitrary.

Further, in his study of strong interpersonal ties, Krackhardt (1992) criticized the definition of tie strength as a continuous variable, which would generate ambiguity as to the strength of each single relationship. Thus, Rowley *et al.* (2000) conceptualize strong and weak interorganizational ties as separate constructs, different in kind rather than degree. They categorize equity alliances, joint ventures, and nonequity cooperative (R&D) ventures as strong ties, while defining marketing agreements, and licensing and patent agreements as weak ties, thereby capturing the strength of interfirm relationships on the basis of the partners' typical levels of interaction in, and resource commitment to, each alliance type. While offering useful insights, this approach is prone to limitations. First, it underestimates the social dimension of the exchange, which the authors deem to be pertinent for individual-level relationships, but not as applicable to interfirm alliances. Second, whereas it may be useful to separate strong from weak ties in a sample including strategic alliances of different types, the operationalization proposed by Rowley and colleagues is of little help for measuring the relative strength of interfirm ties of a single type, as is the case with the research presented here. Finally, by considering *typical* levels of interaction and resource commitment, rather than exploring directly how partners behave, and by focusing on a small number of alliance types, rather than on each single alliance, the authors draw an *a priori* distinction that is unlikely to fit the wide variety of interorganizational relationships and their dynamics.

To overcome the shortcomings of previous research, I offer an operationalization of the strength of interorganizational ties that capitalizes on Granovetter's (1973) original proposal. I therefore conceptualize strong and weak ties as degrees of one another, and I separate clusters of strong and weak ties not by fixing a cut-off value, but instead on the basis of their internal homogeneity and external heterogeneity, which result from a direct

investigation of multiple dimensions of partners' behavior in each single relationship. By doing so, I also build on previous strength-of-ties research at the interorganizational level of analysis, wherein three major aspects of partnering behavior have been advanced to express tie strength: the amount of time that characterizes the tie (Kraatz, 1998), the partners' level of resource commitment (Rowley *et al.*, 2000), and the social contents which develop at both interpersonal and interorganizational levels (Rindfleisch and Moorman, 2001).

Coherently, I frame tie strength as a three-dimensional concept composed of a temporal dimension, a resource dimension, and a social dimension. Thus, strong(er) interfirm ties are characterized by long(er) time-frames and high(er) resource commitments when compared to weak(er) ties, as well as by tight(er) interpersonal relations and trust-based interorganizational linkages. I argue that the following three variables should be employed to express the strength of an interorganizational relationship: (1) the relationship's overall duration; (2) the frequency of collaboration; and (3) the intensity of collaboration. The higher the relationship's duration, and the higher the frequency and intensity of collaboration, the higher the strength of the relationship.

Taken together, duration, frequency, and intensity express the above three dimensions of tie strength. The last two variables measure interaction between partners—the higher the frequency and intensity of collaboration, the more the interaction. They express separate, but equally relevant, aspects of the *temporal dimension* of tie strength, and therefore they need to be jointly taken into account. Consider tie A and tie B, having the same frequency of collaboration: if partners in tie A collaborate more (less) intensely than those in tie B, then they devote more (less) time to the relationship, and hence are involved in a stronger (weaker) tie. Duration completes the assessment of the temporal dimension of tie strength. In fact, for any given level of frequency and intensity of collaboration, the longer (shorter) the relationship's duration, the higher (lower) the overall amount of time spent by partners in the relationship, and hence the stronger (weaker) the tie.

Duration, frequency and intensity also synthesize the *resource dimension* and the *social dimension* of tie strength. On the one hand, other things being equal, long-lived, frequent and intense interorganizational relationships entail higher

resource commitments than short-lived partnerships characterized by low levels of interaction. On the other hand, in some degree, frequency and intensity of collaboration are necessary (although not sufficient) conditions for the social dimension to develop in interfirm partnerships. As interaction increases, interpersonal relations are strengthened and the mutual awareness that provides the foundation for (knowledge-based) interorganizational trust is deepened, thereby also encouraging partners to make higher resource commitments to the relationship. This, in turn, stimulates mutual (deterrence-based) trust, while reciprocity becomes an unwritten rule. Moreover, a long relationship's overall duration allows the above social contents to accumulate and reinforce over time, thereby strengthening the tie. Conversely, the lower the relationship's duration, and the frequency and intensity of collaboration, the thinner the social dimension tends to be, and hence the weaker the tie.

RESEARCH DESIGN

My intent of filling relevant gaps in the extant literature on strategic networks and exploring the rising field of relational capabilities led me to conduct an inductive study. I carried out comparative longitudinal multiple-level case study research with the aim of developing theory from an in-depth examination of three lead firms and the dynamics of their alliance networks. Following Yin (1994), the case study was deemed an appropriate research strategy to help understand the phenomena under investigation within their rich (inter)organizational contexts by relying on several sources of evidence, while the multiple-case comparative approach guaranteed the robustness of the findings (Pettigrew, 1997). The longitudinal structure of the cases, based on a retrospective multiple time-period design, allowed me to measure the innovative performance of each lead firm in subsequent time periods and to observe the network structure leveraged by each company in each period, while also providing multiple observations of the processes through which both single ties and the overall networks affected innovation. The multiple-level structure of the cases produced a study ranging over and across three levels of analysis—the lead firm level, the dyad level, and the network level—in a way that allowed me to

investigate my cross-level research questions thoroughly.

Consistent with a multiple-case research strategy, the study incorporated a replication (rather than a sampling) logic, in which multiple cases are treated as analogous to multiple experiments able to confirm, disconfirm, or refine emerging relationships between significant constructs in an iterative process of theory building (Eisenhardt, 1989; Yin, 1994). In addition, the investigation of multiple time periods in each case, together with both within-case comparisons across subsequent periods and cross-case comparisons, sustained the internal and the external validity of the study.

After an initial groundwork phase, during which I developed my research questions and design and selected the research setting, sample and data sources, I followed a two-stage research process. Stage one integrated quantitative and qualitative data to unravel the linkage between two archetypical network architectures, emerging from the longitudinal analysis of the sample lead firms' alliance behavior, and the lead firms' innovative performance. Stage two relied on the convergence of qualitative information from different sources to advance an explanation of the evidence gathered in the previous stage cutting across the three selected levels of analysis.

Research setting

The research setting is the Italian furnishings industry, which includes the production of furniture, lighting, and complements of furnishings. Here, a number of manufacturers are major international players, whose success is largely dependent on their ability to leverage industrial design as a primary source of continuous product innovation. Instead of relying exclusively on internal design departments, these companies are used to drawing new product ideas and specialized technical skills from networks of dyadic alliances with consulting industrial design firms (design firms, hereinafter), which in turn collaborate simultaneously with manufacturers operating in different industries. This leads to an intricate pattern of interconnected networks that increases the creativity of external designers, by broadening their exposure to knowledge flows, and offers manufacturers a wider spectrum (both in terms of quantity and variety) of stimuli on the aesthetic, functional, and technical sides of innovation. While such a complex web of

relationships is difficult to disentangle, governing the first-order network of design firms has a primary, yet poorly understood, role in the overall strategic management of several Italian design-intensive furnishings manufacturers.

Design firms are usually small (employing not more than five or six individuals), European (often Italian), and highly specialized in industrial design. These firms pivot on their promoting partners, well-known industrial designers (or architects) whose creativity, technical know-how, long-lived relationships with manufacturers, and personal reputations are a major part of the organization's asset base. Following my informants' usage, I describe design firms as 'external designers' and I name each firm using the surname(s) of its promoting partner(s).

Sample

During the groundwork phase, I interviewed the CEOs and managers of numerous firms, and several industrial designers and industrial design scholars. These exploratory interviews were primarily aimed at selecting a small number of leading design-intensive furnishings manufacturers whose strategy hinged upon a network of alliances with design firms. Industry reports, evaluating financial performances and competitive strategies of the leading Italian furnishings manufacturers (Databank, 1997a, 1997b, 1997c), and a questionnaire, aimed at collecting data concerning how they manage innovation, were also employed. As a result, three lead firms—which had described the leveraging of their network of design firms as 'very important' to their adaptiveness, innovation, and

overall performance—were identified for in-depth study.

After originating in the genius of one or a few individuals for design and innovation, the three sample lead firms developed from the efforts of several members of their founders' families, and thus the histories of these companies are deeply intertwined with the vicissitudes of those families. Over the last four decades, these organizations have played a primary role in the history of industrial design worldwide by joint-designing with world-famous external designers, and launching onto the market, 'cult products' that have shaped the imagery and taste of several generations. Table 1 provides an outline of the sample and some basic information on the three lead firms' alliance activity during the investigation period.

Data

The collection of data lasted from September 1998 to October 2000, with an additional wave from March 2003 to October 2003. I employed multiple data collection methods to exploit the synergistic effects of combining them via triangulation (Jick, 1979). Five main sources of evidence were selected.

Archival records

After extensive historical reconstruction, the companies' archives yielded detailed information about the three lead firms' innovative performance and the strength of their alliances with external designers over the investigation period.

Table 1. Sample firms outline

Lead firms	Business areas	Workforce (no. of employees) ^a	Net sales (\$ mill.) ^a	Exports on net sales (%) ^a	Investigation period	Alliance activity during investigation period
B&B Italia	Furniture and complements	501	124.5	69.4	1966–2000	152 joint-design agreements with 30 design firms
Cassina	Furniture and complements	495	128.5	79.1	1970–2000	189 joint-design agreements with 36 design firms
iGuzzini	Indoor and outdoor lighting	848	138.3	59.2	1966–1999	143 joint-design agreements with 33 design firms

^a Workforce, net sales, and exports on net sales refer to 2002.

Retrospective individual interviews

I interviewed the CEOs and several long-standing top managers of the sample lead firms, as well as a number of external designers who had collaborated with the three firms over the investigation period. Interviews were tape-recorded and transcribed. In total, nearly 46 hours of interviews were conducted with 18 individual respondents.

Focused individual interviews

I interviewed the directors of the three lead firms' organizational units (i.e., R&D; Design; Marketing and Sales) directly involved in collaborative activities with external designers. Interviews were tape-recorded and transcribed. Follow-up questions were explored through a combination of face-to-face interviews and telephone conversations. In total, nearly 48 hours of interviews were conducted with 12 individual respondents.

Direct observation

I was able to directly observe events and actors' behaviors throughout numerous field visits. At two study sites I was also allowed to attend 'design reviews'—that is, periodic meetings during which external designers, top managers, technicians, and internal designers discussed new products at subsequent stages of their development processes.

Documentary information

I gathered several materials produced by and about the sample firms, including CD-ROMs, catalogs, and minutes of meetings with external designers. Previous studies, research reports, and books edited by the companies themselves helped the reconstruction of the three lead firms' history. Further information was gathered from the Internet, business press articles, and industrial design journals.

STAGE ONE

In stage one, I defined the outcome variable of the study as the lead firm's *innovative capability*. Following previous studies (e.g., Ahuja, 2000b), in the

empirical research I employed the lead firm's *innovative performance* as a proxy for the firm's capability to innovate. I focused specifically on product innovation performance. Initially, I relied on the interviewees to evaluate how such performance had evolved over time in my three cases. Overall, my interviews generated a picture of three successful companies, whose normally above-average innovativeness had slowed down, however, during multiple-year time periods which I labeled 'opaque phases.' Documentary information and two industry experts corroborated these early findings, and in particular confirmed that the opaque phases had represented a standstill, rather than a collapse, in the firms' innovative performance.

In search of additional quantitative evidence, following my informants' suggestions I considered both 'inside' and 'outside' perspectives on the innovative performance of design-intensive furnishings manufacturers. This led me to select three indicators.

As far as the inside perspective is concerned, I deemed a firm's product innovation output, measured as the number of new products launched onto the market, a first appropriate indicator. From the outside perspective, I first considered market feedback to be especially relevant to express innovation for manufacturers targeting demanding, innovation-oriented customer groups. Given that, in the sample organizations, product portfolio decisions are largely market-driven, including decisions about which products should be withdrawn from the market and when, I captured market feedback for each new product by the number of years between the launch of the product and its withdrawal from the market (i.e., new product duration). Further, following previous studies (e.g., Miller and Shamsie, 1996), I employed the critics' ratings as a third indicator of creativity and innovation. Analogously to what Rao (1994) has found in the automobile industry, success in contests that reward product innovation indeed plays a primary role in the legitimation process for design-intensive manufacturers by helping to establish and reinforce over time a favorable organizational reputation for innovation (see also Gemser and Wijnberg, 2002). I measured the critics' ratings as the number of prize-winning and commended new products in various major innovation-focused contests previously selected by two industry experts.

In each case, my three indicators confirmed that the lead firms' innovative performance had been

systematically lower during the opaque phases and higher during the remaining time periods, which I therefore labeled 'brilliant phases.'

Next, in order to explore a basic idea of my research—that is, both the strength of dyadic alliances and the architecture of the overall network exert a relevant impact on the lead firm's innovative capability—I analyzed longitudinally how the structure of the three networks based around the sample lead firms had evolved over time across the brilliant and opaque phases. As discussed earlier, I operationalized the strength of each single manufacturer–design firm alliance as a linear combination of the following variables: the relationship's *overall duration*, measured as the overall time-span (expressed in years) between the subscription of the first joint-design agreement and the launch of the last joint-designed new product; the *frequency of collaboration*, measured as the number of individual years in which the manufacturer and the design firm had actually collaborated on joint activities during the relationship's overall duration; and the *intensity of collaboration*, measured as the number of joint-design agreements signed during the relationship's overall duration.

For each case, archival records allowed me to create a relational database containing information on the overall duration, and on the frequency and intensity of collaboration, of every dyadic joint-design alliance held by the lead firm during each single phase. As the three lead firms did not file hard data about 'failures' (i.e., agreements that had not yielded finished products), I included only formal agreements that had resulted in at least one finished product. I then calculated standardized measurements to remove the scale effect. I employed the mean absolute deviation for data standardization. Following Hampel *et al.* (1986), I deemed it a more robust (i.e., less sensitive to outlying values) dispersion measure than the standard deviation. For each historical phase, this allowed me to obtain a standardized data matrix, which I analyzed through the following analytical steps.

First, I used principal component analysis (PCA) to reduce the number of initial variables by constructing new, uncorrelated variables (i.e., principal components) that are linear combines of the initial ones and retain decreasing percentages of total inertia from the original data (Bouroche and Saporta, 1983; Jolliffe, 1986). For each lead firm

and every historical phase, PCA results revealed a split in the network between a 'core' of strong(er) ties and a 'periphery' of weak(er) ties. Second, I turned to cluster analysis (CA) to design the boundaries between core and periphery, thereby ascertaining their size and composition (Everitt, 1974). I employed two CA techniques—a non-hierarchical technique based on MacQueen's (1967) *k*-means method and an ascendant hierarchical technique (Ward, 1963)—in order to cross-check their results (Bouroche and Saporta, 1983). Finally, I compared the results of the two previous analytical steps across the phases, so as to shed light on the dynamics of the network structure in each case.

Alternative network structures and lead firm innovation

Table 2 shows the brilliant (white rows) and the opaque (shaded rows) phases that emerged from the longitudinal analysis of the sample lead firms' innovative performance, together with representative excerpts from the interviews. Note that the cut-off years between the phases were set on the basis of my retrospective interviews and conversations with two industry experts. In sum, while the history of B&B Italia and the history of iGuzzini show two short opaque phases interrupting three longer brilliant phases, for Cassina a single 8-year opaque phase divides two longer brilliant phases.

For each case and every phase, my analysis of the relational databases yielded significant and strong correlations among the three initial variables. Therefore, the PCA results summarized in Table 3³ show that the first principal component (PC1) always accounts for a high percentage of total inertia (between 90.16% and 99.16%). Moreover, PC1 is always strongly and positively correlated with the initial variables (≥ 0.90). Thus, the coordinates of the design firms on PC1 faithfully express tie strength: the higher the coordinate, the stronger the corresponding tie. Those coordinates are employed in Figure 1 to produce graphical displays of the networks in which lines represent alliances, and the distance of each design firm (i.e., each dot) from the lead firm (i.e., the empty circle at the center of each network)—or, in other words, the length of each line—is inversely proportional

³ Full PCA results are available from the author upon request.

Table 2. B&B Italia, Cassina, and iGuzzini: brilliant and opaque phases

Lead firms	Phases	Average number of new products per year	Average duration of new products ^a (years)	Prize-winning		Commented
				Average number of winning and commented new products per year ^b	Commended	
B&B Italia (1966–2000)	Phase 1 (1966–1974)	4.11	13.18	0.11	0.11	
	Phase 2 (1975–1978)	2.00	7.87	0.00	0.00	
	Phase 3 (1979–1986)	4.62	10.32	0.87	0.37	
	Phase 4 (1987–1991)	3.00	7.60	0.00	0.20	
	Phase 5 (1992–2000)	7.11	–	0.22	0.11	
Cassina (1970–2000)	Phase 1 (1970–1980)	5.73	13.41	0.73	0.09	
	Phase 2 (1981–1988)	4.37	9.86	0.00	0.00	
	Phase 3 (1989–2000)	7.58	–	0.17	0.08 ^c	
iGuzzini (1966–1999)	Phase 1 (1966–1968)	9.33	9.28	–	–	
	Phase 2 (1969–1975)	2.57	6.72	–	–	
	Phase 3 (1976–1980)	4.60	9.00	–	–	
	Phase 4 (1981–1985)	2.60	7.04	0.00	0.00	
	Phase 5 (1986–1999)	3.93	–	0.79 ^c	0.07	

Excerpts from the interviews

'[In phase 1] we experimented with new manufacturing processes and lots of new materials. We also created many joint-design alliances with design firms employing diverse technologies and product styles. All this yielded very innovative products, many of which have been featured in our catalogues until recently. ... We also achieved excellent innovative outcomes during [phase 3]. ... In those years, the critics were particularly generous to us, and this sustained both our sales and reputation.' (Director, R&D Department)

'it's common knowledge here that our innovativeness slowed down twice, during [phase 2 and phase 4]. ... However, although in both cases this company was not an outstanding innovator, it still remained a relevant actor in the industry. This was probably due to our ability to keep alive the dialogue with partners with which we had close links, and hence with people on the same wavelength as us. ... At the same time, however, our reliance on a small number of external designers blurred our capability to pick up and develop cool ideas to some extent.' (Director, R&D Department)

'The '70s were a very successful decade for Cassina. We allied with a number of designers, whose unique creativity, combined with our first-rate capabilities in R&D, manufacturing and marketing, yielded many innovative products. ... Both the market and the critics rewarded our efforts.' (A manager from the Marketing Department)

'During the '80s, we had to contend with a general taste that looked back to the past. Results were fairly good, although our leadership in innovation was jeopardized. ... But, in the end, we came out of it unharmed.' (A manager from the Marketing Department)

'After the honors of the '70s, we had troubled times during the '80s, but in the 90's this company turned out again to be a top performer in its strategic group.' (CEO)

'[In phase 1] we achieved excellent innovative outcomes. Our network of external designers was exceptionally prolific and we launched many new products that would stay in our product portfolio and catalogs for many years.' (CEO)

'During the first half of the '70s, our innovative vein was about to run out and our new products didn't seem to be so appealing to customers as they had been in the past. ... But in the second half of the decade we recovered our inspiration. Such a sudden change of direction was probably due to our deliberate search for new designers. Although we only had 'one-shot' relationships with many of them, on the whole these new partners widened our horizons. Above all, they helped us to establish our brand in technical lighting, a new business we entered in the early '80s. ... Unfortunately, all this came to a standstill [in phase 4].' (Director, Research Center)

'Since the second half of the '80s, we have been through a very positive phase. ... We have fully recovered our innovative vein, thanks to a well balanced mix of strong and weak relationships with external designers. ... During the last twenty years we have been winning awards like water.' (Director, Research Center)

^a Due to data censoring, the duration of new products is not significant for the last phase in each case.

^b Archival records of iGuzzini about new product awards and commendations start in 1980, and hence only cover Phases 4-5.

^c The company was also awarded a Special Mention for its whole collection at the 1991 edition of the "Compasso d'Oro" competition.

Table 3. B&B Italia, Cassina, and iGuzzini: summary of PCA results

Lead firms	Phases	First principal component (PC1)		Correlations between PC1 and initial variables		
		Eigenvalue	% of total inertia	Duration	Frequency	Intensity
B&B Italia	Phase 1	2.97	99.07	0.99	1.00	0.99
	Phase 2	2.96	98.70	0.99	0.99	1.00
	Phase 3	2.79	93.12	0.91	0.95	0.98
	Phase 4	2.98	99.16	0.99	1.00	1.00
	Phase 5	2.72	90.68	0.96	0.97	0.91
Cassina	Phase 1	2.71	90.16	0.97	0.98	0.90
	Phase 2	2.77	92.21	0.97	0.96	0.95
	Phase 3	2.71	90.21	0.96	0.96	0.93
iGuzzini	Phase 1	2.72	90.70	0.97	0.97	0.92
	Phase 2	2.88	96.10	0.99	0.99	0.97
	Phase 3	2.81	93.66	0.97	0.99	0.95
	Phase 4	2.97	98.95	0.99	1.00	0.99
	Phase 5	2.74	91.37	0.98	0.97	0.91

Table 4. B&B Italia, Cassina, and iGuzzini: network structure in brilliant and opaque phases

Lead firms	Phases	Percentage of total network membership (no. of design firms)		Percentage of total relationships' duration (years)		Percentage of total frequency of collaboration (years)		Percentage of total intensity of collaboration (no. of agreements)	
		Core	Periphery	Core	Periphery	Core	Periphery	Core	Periphery
		B&B Italia	Phase 1	18.2	81.8	42.9	57.1	42.1	57.9
	Phase 2	75.0	25.0	86.4	13.6	85.2	14.8	87.5	12.5
	Phase 3	23.1	76.9	41.0	59.0	41.0	59.0	51.4	48.6
	Phase 4	75.0	25.0	86.2	13.8	86.7	13.3	93.3	6.7
	Phase 5	15.4	84.6	40.9	59.1	37.5	62.5	64.1	35.9
Cassina	Phase 1	22.2	77.8	41.5	58.5	44.6	55.4	58.7	41.3
	Phase 2	70.0	30.0	80.5	19.5	80.4	19.6	85.7	14.3
	Phase 3	21.4	78.6	48.3	51.7	41.5	58.5	56.0	44.0
iGuzzini	Phase 1	18.2	81.8	32.1	67.9	32.1	67.9	66.7	33.3
	Phase 2	66.7	33.3	76.5	23.5	80.0	20.0	88.9	11.1
	Phase 3	27.3	72.7	38.5	61.5	43.3	56.7	56.5	43.5
	Phase 4	75.0	25.0	88.0	12.0	88.5	11.5	92.3	7.7
	Phase 5	15.4	84.6	38.2	61.8	38.0	62.0	54.2	45.8

to the strength of the relationship between them: the longer the distance, the weaker the tie. Note that, since the coordinates of the design firms on PC1 allowed me to calculate the distances between every pair of the *n* design firms, rather than the distances of each individual design firm (df) from the lead firm, for each phase I set the distance between the strongest contact (df₁) and the lead firm (lf) equal to 1 (D_{df1-lf} = 1), so as to calculate

the distances of the remaining *i* contacts from the lead firm (D_{dfi-lf}; *i* = 2, 3, ..., *n*) as follows:

$$D_{dfi-lf} = D_{df1-lf} + D_{dfi-df1} = 1 + D_{dfi-df1}$$

The graduated axis on the northwest side of each display helps the reader evaluate and compare the above distances, and hence the strength of the corresponding ties. Figure 1 shows the core of strong

contacts (underlined and closer to the lead firm) and the periphery of weak contacts (farther from the lead firm) for each of the three firms in every phase. However, quite different *proportions* of strong and weak ties can be observed between the brilliant (white areas) and opaque (shaded areas) phases. For each phase the two CA techniques yielded identical results for membership of the networks' core and periphery, which are shown in Figure 1 separated by dotted circles.

Although strong and weak ties coexist in every phase, Figure 1 suggests two different archetypical network structures, whose distinctive features emerge from data reported in Table 4. In the opaque phases (shaded rows), the network core of strong ties appears to cover a large proportion of total membership in the network (between 66.7% and 75%) and to account for the preponderant share of the lead firm's overall alliance activity in terms of relationships' duration (between 76.5% and 88%) and of frequency (between 80% and 88.5%) and intensity (between 85.7% and 92.3%) of collaboration with external designers. Conversely, weak ties play a marginal role. Hence, the alliance web can be said to show a strong ties network architecture.

On the contrary, in the brilliant phases (white rows), weak ties prevail over strong ties in numerical terms, holding the major proportion of total membership in the network (between 72.7% and 84.6%). When compared to the opaque phases, the network periphery of weak ties accounts for a quite larger share of the lead firm's overall alliance activity in terms of relationship duration (between 51.7% and 67.9%) and of frequency (between 55.4% and 67.9%) and intensity (between 33.3% and 48.6%) of collaboration with external designers. However, as strong ties also play a significant role by absorbing a considerable share of the lead firm's overall alliance activity, in the brilliant phases the alliance web displays what I label a dual network architecture.

In summary, during stage one, my analysis of the dynamics of the innovative performance of the three lead firms and the structure of their networks revealed that a strong ties network architecture and a dual network architecture had alternated over a time lapse of more than 30 years, and that the former had characterized the opaque phases while the latter had prevailed during the brilliant phases.

STAGE TWO

In search of an explanation of an apparent association between the structure of the three networks under investigation and the innovative performance of their lead firms, following a customary path in network research I started from the dyad level of analysis. Here, specifically at the intersection with the firm level, I realized the potential of strong dyadic ties for innovation. I also noticed that, in my three cases, this potential had spread across both the opaque and the brilliant phases. However, moving upward from the dyad level to the network level and focusing on the intersection between the network level and the firm level I found that, when strong ties networks had prevailed (i.e., during the opaque phases), the potential of strong dyadic ties for innovation had been partially offset by the pitfalls of a strong ties network architecture, thereby slowing down the innovative performance of the three lead firms. Conversely, when the lead firms had leveraged dual networks (i.e., during the brilliant phases), the advantages of a large periphery of weak ties had countered the potential disadvantages of a strong ties network, and the benefits of a network architecture combining the strengths of strong and weak ties had emerged, thereby leading to outstanding innovation. Following this line of explanation, I outline below the strengths of strong ties, the weaknesses of a strong ties network, and the strengths of a dual network.

Strengths of strong ties

The fieldwork suggests the following three categories of strong ties' strengths to explain the relevant contributions of strong dyadic ties with external designers to the lead firms' innovative performance across the opaque and the brilliant phases.

The first category refers to mutual knowledge. Manufacturers and design firms involved in strong ties accumulated over time a thorough reciprocal knowledge of each other's resources, technical know-how, design competencies, and organizational routines, together with a deep mutual understanding of cultural traits and long-term objectives. This impacted positively the lead firms' innovative outcomes in a number of ways. First, it allowed the manufacturers to select appropriate partners for additional joint-design agreements in

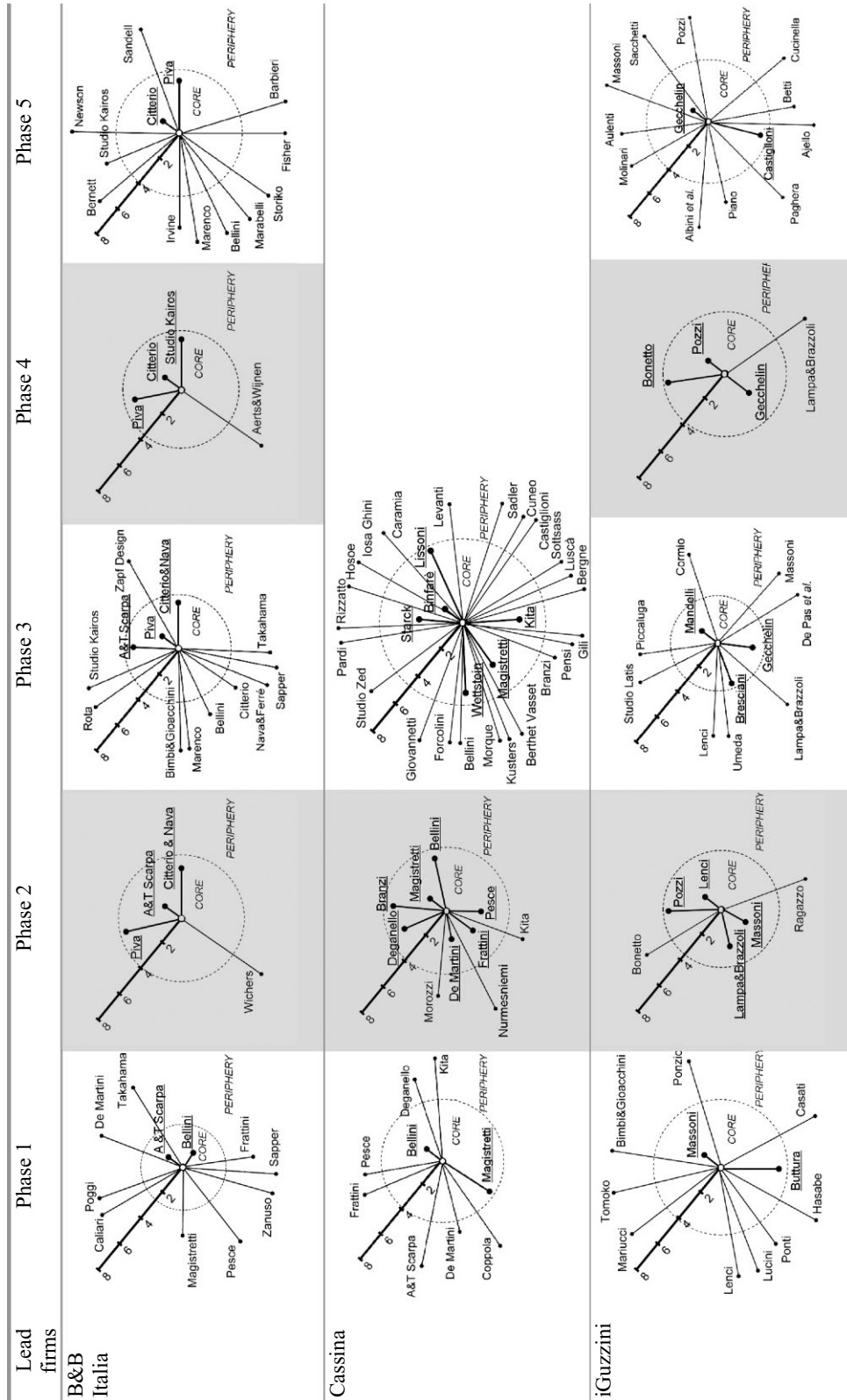


Figure 1. Strong and weak ties in B&B Italia, Cassina, and iGuzzini networks

a way that significantly increased the probability that the resulting products would be coherent with the company's overall design philosophy or with a particular style. Second, it reduced time to market by facilitating and speeding up interorganizational interaction along the entire new product development process. Third, a deep mutual knowledge increased joint-design effectiveness by putting the design firms in a favorable position to either (a) pick up and interpret new product ideas that, while shared among the organizational actors across the allied firm in latent forms, would hardly take shape without an external facilitator, or (b) advance totally new product ideas able to sustain the partner's competitive orientation or support change in its business strategy, or even to dictate major developments in its corporate strategy (e.g., entering a new business).

Thus, according to a manager from the R&D Department of Cassina:

The overall quality of a joint-design process is strongly affected by a history of cooperation. In our experience, the best results are typically attained after the parties have developed a thorough mutual understanding over time. . . . At first, wariness prevails and neither we nor external designers give ourselves away. Later on, as knowledge of the people involved in the relationship deepens and trust develops, formal patterns of interaction are usually set aside and we get on the same wavelength with our partners. At this point, real collaboration takes off and new products take shape smoothly, capitalizing on lessons learned and on 'broadband' information exchange.

The second category of strong ties' strengths includes the importance of interorganizational trust and reciprocity, and of the underlying interpersonal relationships between individual members of the partnered organizations. As the Director of Cassina's R&D Department put it:

Mutual trust, reciprocity between partners, and feeling among individuals: these are the ingredients for successful partnerships. . . . Time and repeated interactions are essential to develop such favorable conditions. First-class innovation will be a logical consequence.

Interorganizational trust and its leverage on knowledge sharing and innovation deserve special attention. Both manufacturers and external designers involved in strong, trust-based relationships were willing to pool their assets and to share

their knowledge with partners in the awareness that proprietary know-how would not be absorbed and exploited opportunistically by the other party, let alone transferred to competitors. Indeed, the parties' concern for reputation induced manufacturers to carefully avoid unilateral exploitations of new product ideas suggested by external designers, while also preventing designers from leaking their partners' industrial secrets and strategic plans to competitors. Analogously to what Hagen and Choe (1998) reported in their study of buyer-seller relationships in the Japanese auto industry, my direct observations during the 'design reviews' and my informal conversations with the three lead firms' CEOs and with external designers highlighted the way societal sanctioning and the rapid spreading of reputation in social networks discouraged opportunistic behaviors on either side, thereby promoting mutual trust and hence open-ended and knowledge-intensive cooperation.

In addition, the sample manufacturers engendered trust in their strong relationships with design firms proactively through informal agreements by which external designers agreed to joint-design given products (e.g., sofas and/or tables, or indoor and/or outdoor lighting appliances) exclusively with specific manufacturers. Such informal safeguards had positive effects on innovation processes and their outcomes by encouraging the manufacturers to participate in knowledge-transfer activities. At the same time, being strictly limited to certain product categories, such exclusive agreements did not jeopardize the design firms' ability to come up with new ideas by brokering knowledge across diverse industries.

Furthermore, social and affective contents (and sometimes real friendship) flowed from the interpersonal linkages underlying the interorganizational relationships and were nourished through that deep feeling of challenge that joins individuals involved in the development of new products. Together with the awareness of partner's trustworthiness resulting from previous long-lived and repeated interactions, those contents encouraged participants in strong ties to increase their emotional investments in the relationship and to cooperate well beyond contractual provisions in the pursuit of innovation. Once such a collaborative atmosphere had been created, the entire manufacturer's organization became ready to join the external designer in testing ground-breaking design approaches and developing innovative products.

At the same time, the designer became willing to serve as a 'sheet anchor' for his/her partner (e.g., by designing new products in record time, in order to meet urgent customer needs or counteract unexpected competitor moves), or even to accept that his/her 'bold projects' might be set aside or delayed for competitive or market reasons. While signaling open-ended and effective cooperation, these emerging patterns of mutual adjustment helped partners to find the right balance between their innate propensity to explore new trajectories, leading to a relentless search for path-breaking innovation, and more conservative approaches pursuing competitive effectiveness and easier acceptance of new products by customers, with positive effects on the overall innovation performance.

The third category of strong ties' strengths includes actions taken and investments made by the participating organizations in the belief that interfirm alliances can positively influence performance on both sides and that the destinies of partners tied by a strong relationship are deeply intertwined. External designers involved in strong ties were willing to promote new products toward customers, to deliver market feedback to the manufacturers, to suggest how to improve existing products and to submit new product ideas to their partners. While clearly driven by immediate economic incentives, these actions were also intended to be acts of commitment, in response to which the manufacturers were ready to allocate resources to the joint definition of new product styles or to finance marketing initiatives in support of their partners' identity, in the awareness that two organizations tied by a strong relationship build each other's reputations. Thus, both the partners' level of resource commitment to the relationship and the lead firm's potential for innovation grew substantially.

In particular, relation-specific investments in physical and human assets were made on either side in a way that tailored processes, organizational competencies, and human skills to particular partners, with positive effects on the pursuit of innovation. The lead firms acquired machinery and technical know-how to employ their design partners' favorite materials, while at the same time external designers learned to specialize in designing product lines included in the manufacturers' catalogs, or to develop idiosyncratic skills needed to exploit exclusive technologies mastered by their partners. The rationale for these investments lay

in interorganizational trust and interpersonal relationships, which fostered a strong confidence that they would be reciprocated by the other side and that the resulting advantages would be shared between partners. Through such investments, manufacturers and designers signaled to each other their willingness to prolong their cooperation and stimulated further reciprocal acts of commitment, thereby driving the relationships further along their developmental processes (Anderson and Weitz, 1992; Ring and Van de Ven, 1994) and ultimately strengthening the ties at both interorganizational and interpersonal levels.

Weaknesses of a strong ties network

Despite the advantages of strong dyadic ties, my fieldwork suggests that the 'dark side' of a strong ties network may explain an apparent irony—that is, why the innovative performance of each sample lead firm slowed down during time periods in which strong ties accounted for the dominant proportion of both total network membership and the lead firm's alliance activity.

First, when these conditions occurred, and hence weak ties played a marginal role, the three manufacturers found themselves locked in a narrow circle of strong ties, and thus dependent on the inspiration of only a small number of external sources of creativity. This constrained the lead firms' ability to gain access to novel ideas and to generate truly new products, which in turn resulted in the 'opaqueness' of the corresponding historical phases. In addition, the small network size reduced the lead firms' bargaining power in each single relationship and increased their risks of failure should network players be lost.

Second, when playing the leading role in a strong ties network, the three manufacturers found themselves at least partially locked out of the innovative stimuli continuously arising within the 'design world.' Moreover, they also lacked that large and diverse knowledge base needed to evaluate new external designers thoroughly, or to appreciate their potential for contributing to the pursuit of innovation. At the same time, the flexibility of the lead firms' organizational routines to interact with multiple asymmetric partners declined. All this limited the firms' ability to perceive new trends and to keep abreast of technological evolutions, while also threatening their cultural attitude toward, and organizational reactivity to, change.

Third, for the three lead firms, blindness toward new partners also decreased strategic responsiveness to social and economic changes. Marketing strategies became overfocused on the existing targets and risks of losing contact with emerging customer groups increased. As a result of such a long distance from new market trends, the best chances to anticipate market evolution, to sense new opportunities, and to create new forms, functions, and lifestyles were missed. In addition, the lead firms' reputations suffered, and the companies and their managers became portrayed as being opposed to newness and bold innovations, further undermining the firms' competitiveness.

The weaknesses inherent in a strong ties network are summarized in the words of iGuzzini's CEO:

Although the history of iGuzzini has been characterized by some very close relationships with external designers, and even though for some brief periods we yielded to the temptation to tie ourselves tightly to just one or a small number of external designers, it was clear for me from the very beginning that gambling on a few such partnerships wouldn't be the best strategy in the long run. How would we get to know of the latest technological innovations and their applications? How would we find out the hottest trends in forms? How would we be aware of the tastes and needs of disparate customer groups in different continents? ... To do these things well, we need to maintain many and diverse 'antennae' in multiple directions, letting our partners smell out new trends or gather innovative stimuli from multiple sources.

Strengths of a dual network

During the brilliant phases, the three design-intensive furnishings manufacturers avoided the weaknesses of a strong ties network by leveraging a dual network architecture including a large periphery of weak ties. The following advantages of such an alliance behavior worked together to generate superior innovation.

First, a large number of weak ties eliminated the hazards of being locked in a restricted number of relationships. Interestingly, and consistently with previous research (Powell *et al.*, 1996; Simonin, 1997), the interviewees also argued that interacting with several design firms fostered learning processes, resulting in rapid accumulation of both individual skills and organizational capabilities to create and manage interfirm collaborative relationships, thus laying the foundations for further network development.

Second, contributions from numerous partners amplified variance within the network. The three manufacturers purposely created a large periphery of weak ties to collaborate with external designers that employed diverse technologies and materials, and to come into contact with a variety of design approaches, expressive languages and styles (Cassina), or at least to experiment with multiple different interpretations of the company's design philosophy (B&B Italia) or even of a well-defined style (iGuzzini). Moreover, repeated interactions with a large number of network nodes forced the lead firms to master diverse approaches to organizing joint-design activities, thereby enhancing the flexibility of both their internal procedures and routines for interorganizational interaction. Thus, weak ties avoided redundancy within the network. Over time, they made considerable contributions to the lead firms' knowledge base, which in turn increased the firms' attractiveness toward external designers, whether they were already part of the network or potential partners.

Third, a major effect of the resulting inwardly diverse networks was an increasing openness of both the overall networks and their leading actors toward new market trends. During the brilliant phases, while entrusting strong ties with the primary task of satisfying already targeted customers, the three manufacturers tended to leverage their numerous weak contacts to approach 'new' (i.e., previously untargeted) market segments, to open windows on trendsetter geographical markets (e.g., the United States) and customer groups (e.g., the 'hippies' during the late 1960s, or the 'yuppies' around the mid 1980s), and to throw sensors into emerging geographical markets (e.g., China), product markets (e.g., outdoor lighting), and customer groups (e.g., new generations). Overall, weak ties were frequently employed to support proactive strategies aimed at nurturing new lifestyles through innovative product concepts jointly conceived with external designers.

In summary, during the brilliant phases, the sample lead firms deliberately created and nurtured a large periphery of heterogeneous weak ties with the aim of escaping redundancy and increasing the diversity of their networks. Thus, they avoided the risks inherent in a strong ties network while continuing to enjoy the strengths of strong ties. According to the Director of B&B Italia's R&D Department:

Our mission is to generate product innovation relentlessly, and therefore we cannot concentrate our partnering efforts on a few strong contacts exclusively. . . . Strong ties are valuable reference points, but we must not avoid continuously building a large number of new alliances with design firms that have the potential to carry us on new paths. It's a matter of bargaining power. . . . Above all, it's a matter of flexibility: these [weak] relationships allow us to stay flexible toward multiple and fast-changing product technologies, materials, design approaches and procedures, styles, markets, and customers' needs.

DISCUSSION

This study examines how three lead firms managed their strategic networks of knowledge-intensive alliances over more than 30 years. My longitudinal case studies illustrate the role of strong dyadic ties in sustaining lead firm innovation during the entire investigation period. They also show that, over time, the sample lead firms alternated two different network architectures, whose different impact on innovation is a major explanation of a succession of opaque and brilliant phases in the firms' histories. The overall theoretical contribution of this paper is discussed in the present section and summarized in Figure 2, which sketches out a cross-level preliminary model of the impact that strong dyadic ties, a strong ties network, and a dual network exert on the lead firm's innovative capability over time.

At the dyad level of analysis, and focusing specifically on the intersection with the firm level, the cases suggest that the strengths of strong ties—mutual knowledge, social contents, and relation-specific investments—sustain the lead firm's capability to innovate repeatedly. Besides operating individually, the three sources of strong ties' strengths reinforce each other over time in a virtuous circle. Indeed, a thorough mutual knowledge is a prerequisite for social contents to develop in interfirm alliances, as well as for relation-specific investments. In turn, the development of the social aspects of economic exchange not only contributes to the deepening of mutual knowledge by means of 'fine-grained information transfer' (Uzzi, 1997) concerning proprietary know-how and confidential information, but also encourages the participating organizations to intertwine their destinies by investing in relation-specific assets (Dyer, 1996). Relation-specific investments

in physical and human assets increase the economic interests at stake and, when balanced between partners, demonstrate mutual commitment. This further stimulates the development of social contents and sets the relationship on tracks of reciprocity, laying the foundations for future interactions, and hence for the deepening of mutual knowledge. Finally, as mutual commitment, fueled by the making of relation-specific investments on both sides, increases along the relationship developmental process, mutual dependence between the exchange partners also grows incrementally, in turn exerting a positive effect on the relationship value creation (Blankenburg Holm, Eriksson, and Johanson, 1999).

Long-lasting, frequent, and intense dyadic inter-organizational collaboration is the fundamental driver of the process outlined above, wherein growing trust is an intermediate product that leads the process into subsequent cycles, and an increased innovative capability is the major outcome at the lead firm level. Over time, as strong-tied partners interact repeatedly, they learn about each other, while the social side of economic exchange develops (Larson, 1992) and specialized knowledge is accumulated (Doz, 1996; Dyer and Singh, 1998), thereby further strengthening the tie. Trust stimulates close interpersonal interaction and mitigates fear of opportunistic behaviors (Kale *et al.*, 2000; Zaheer *et al.*, 1998), helping partners to overcome the organizational safeguards that companies involved in knowledge-intensive alliances typically set up to limit uncontrolled information disclosure. The resulting cross-fertilization of the participating organizations' knowledge bases is a preliminary condition for knowledge creation—and hence for innovation—to occur in interfirm alliances.

Trust *emerges* from repeated interactions (Good, 1988; Gulati, 1995), as interfirm relationships evolve through their developmental processes (Ring and Van de Ven, 1994). In addition, prior research shows that firms that hold the reins of networks purposely *build* interorganizational trust to facilitate interfirm knowledge transfer (Dyer and Nobeoka, 2000). Coherent with this, my findings suggest that lead firms can stimulate innovation by deliberately fostering an atmosphere of trust within their network ties through exclusive agreements whose scope is narrow and well defined.

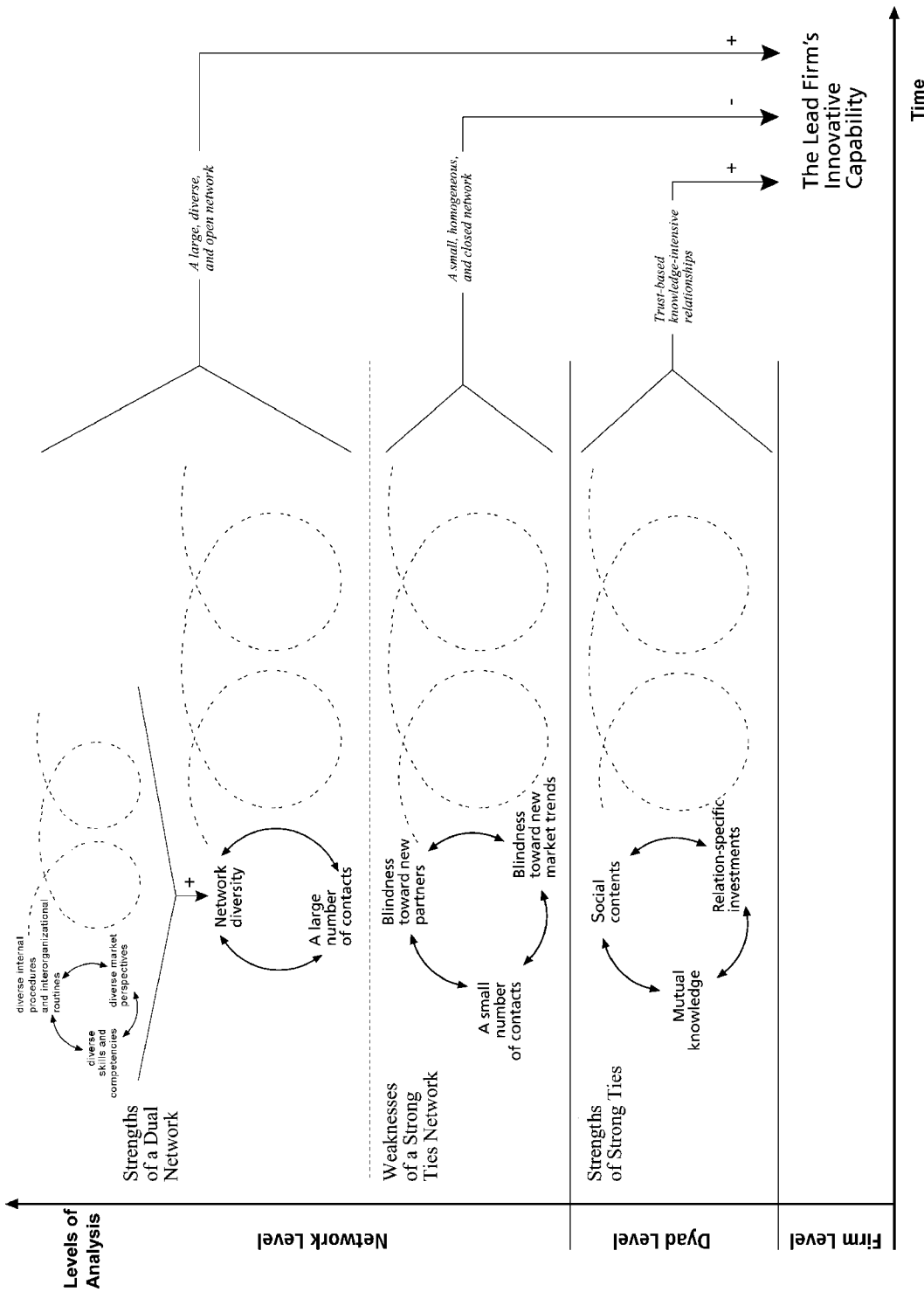


Figure 2. The theoretical contribution

Such arrangements promote open-ended cooperation and knowledge sharing within dyadic relationships without discouraging partners from brokering across diverse knowledge domains outside the relationships.

The above arguments suggest the following proposition:

Proposition 1: Over time, strong dyadic ties exert a positive impact on the innovative capability of the lead firm in an alliance network by promoting a virtuous circle in which the deepening of mutual knowledge, the development of social contents between partners, and the making of relation-specific investments on both sides reinforce each other, resulting in trust-based knowledge-intensive relationships.

Lead firms that take advantage of the strengths of strong ties, however, may also face the weaknesses of a strong ties network. The danger of being locked in a narrow circle of strong ties and the risk of becoming unable to face technological discontinuities or profit from new opportunities—whether they spring from heterophilous relationships or new market trends—are major hazards for the leading actor in a strong ties network. In fact, they may jeopardize the lead firm's ability to generate, or to respond to, change. This is also due to the marginal role weak ties play in a strong ties network, preventing the periphery of the network from exerting significant influence on innovation.

As Burt (1992) pointed out, network size and diversity are major concerns in network management (see also Baum *et al.*, 2000): numerous repeated ties to too small a number of partners generate isomorphism within the network, thereby decreasing network diversity and the lead firm's access to nonredundant knowledge. Thus, the hazards of a strong ties network not only operate individually, but also reinforce each other over time in a vicious circle in which long-lasting, frequent, and intense interorganizational collaboration with a small number of core contacts becomes the fundamental driver, the decreasing growth rate of the lead firm's knowledge base is an intermediate product that leads the process into subsequent cycles, and a diminished innovative capability is the major outcome at the lead firm level.

Previous research suggests a positive relationship between number of alliances and organizational innovation output (Ahuja, 2000a; Shan,

Walker, and Kogut, 1994). Network membership and tie modality matter too (Gulati *et al.*, 2000). Thus, the more the lead firm is strong-tied to a small number of homogeneous contacts, the more it becomes blind toward the possibilities of new partners, and hence the more homophily and overembeddedness tend to slow down the development of its knowledge base. At the same time, the flexibility of the lead firm's internal procedures and organizational routines for interfirm interaction gradually decreases. Where the lead firm systematically relies on its network to detect customers' needs, the small network size and an inadequate organizational flexibility, which hinders interaction with new partners, will also lead the firm and its network to become out of step with market demands. Following this path, the growth rates of both the lead firm's knowledge base and its customer base rapidly decrease, and hence the firm's attractiveness toward potential partners becomes seriously damaged, preventing the organization from gaining access to fresh external sources of creativity, which in turn further insulates the network from new market trends. Thus, a spiral is triggered off which leads over time to a small, homogeneous, and closed network that exerts a negative impact on the lead firm's innovative capability. Therefore, the following proposition is advanced:

Proposition 2: Over time, a strong ties network architecture exerts a negative impact on the innovative capability of the lead firm in an alliance network by promoting a vicious circle in which reducing numbers of contacts, decreasing flexibility for collaboration with new partners, and diminishing responsiveness to new market trends reinforce each other, resulting in a small, homogeneous, and closed network.

The above observations are especially relevant to firms, such as the three design-intensive manufacturers in the present study, that rely on large-scale interfirm collaboration to keep pace with continuous technological and market developments, to sustain their organizational flexibility, and to pick up and develop new product ideas. During the opaque phases, the sample firms suffered from the weaknesses of their strong ties networks. Conversely, during the brilliant phases, they enjoyed the strengths of strong ties and avoided the weaknesses of a strong ties network architecture by leveraging dual networks, which saw their core

of strong ties integrated with a large periphery of weak ties, thereby increasing both network size and diversity. Such strategic behavior reveals a lead firm's distinctive relational capability, one that capitalizes on the strengths of a dual network architecture to create favorable conditions for sustained competitive advantage based on superior innovation.

For the lead firm in a dual network, the increase in network size associated with having numerous weak ties eliminates the hazards of small-numbers bargaining. A large number of partners reduces indeed the vulnerability of the firm to its external sources of innovation failing, drying up, or exiting the network, thereby enhancing the company's bargaining power in each dyad. At the same time, a large periphery of weak ties significantly increases network diversity. Thus, continuous interplay between a growing number of contacts and an increasingly heterogeneous web of partners generates over time a large, diverse, and open network that exerts a positive impact on the innovative capability at the lead firm level. Network diversity is key. My three cases have highlighted three major sources of network diversity and their advantages for the lead firm in a dual network. These three sources result from the network nodes' heterogeneity in terms of (1) technical skills and organizational competencies, (2) internal procedures and routines for interorganizational interaction, and (3) market perspectives.

Thanks to the first source of network diversity, the leading actor can rely on multiple different sources to *access* various skills and mobilize heterogeneous competencies (Grant and Baden Fuller, 2004), as well as to *learn* new knowledge (Beckman and Haunschild, 2002). In particular, when learning occurs, the lead firm's absorptive capacity is enhanced, thereby increasing the organization's capability to innovate (Cohen and Levinthal, 1990). In addition, the company's attractiveness toward both existing and potential partners is improved, creating fertile ground for further network development.

The second source of network diversity forces the lead firm to adapt its own internal procedures and to develop flexible routines for knowledge-intensive interorganizational interactions. In turn, this enhances the organization's capability to interact effectively with a large number of heterogeneous partners. The resulting flexibility allows

the lead firm to integrate and recombine knowledge inputs from multiple heterogeneous network nodes, thereby actualizing the potential for knowledge creation residing in its alliance network. Flexible routines also allow the lead firm to adjust the composition of the network quickly, thereby increasing the firm's ability to adapt in the face of environmental changes which might render its partners' capabilities outdated.

The third source of diversity offers the lead firm in a dual network valuable intelligence of, and different angles on, the preferences of both already-targeted customer groups and geographical markets or market segments beyond its usual scope. This can support the company's existing marketing strategy and/or drive it toward new targets, opening the overall network and its leading actor toward new market trends.

The above three sources of network diversity and their advantages reinforce each other over time. The flexible (inter)organizational routines developed from interactions with multiple heterogeneous partners allow the lead firm in a dual network to make the most of its web of contacts' potential both to learn new knowledge by interacting with its partners, and to enlarge its customer base. As the lead firm repeatedly absorbs, from different partners, information on new customer groups and knowledge to satisfy their needs, a virtuous co-evolution develops between the firm's customer base and its knowledge base, thus laying the foundations for sustained competitive advantage based on a truly dynamic innovative capability.

The above findings and arguments suggest the following propositions:

Proposition 3: Over time, a dual network architecture exerts a positive impact on the innovative capability of the lead firm in an alliance network by promoting a virtuous circle in which growing numbers of contacts and increasing network diversity reinforce each other, resulting in a large, diverse, and open network.

Proposition 4: The leveraging of a dual network architecture is a distinctive relational capability that allows the lead firm in an alliance network to gain and sustain competitive advantage based on a dynamic innovative capability.

CONCLUSION

This paper contributes to the growing debate on strategic management of knowledge-intensive alliance networks by taking the perspective of the lead firm and stressing the importance of relational capabilities as dynamic sources of competitive advantage. In a recent contribution, Gulati *et al.* (2000: 207) pointed out that the structural pattern of a firm's relationships can be an inimitable resource. The present research shows that, in order to exploit the potential for competitive advantage embodied in interorganizational network ties, lead firms should *manage* the structure of their networks carefully. Founding upon comparative longitudinal case study research of three lead firms, I submit that the ability to integrate a large periphery of heterogeneous weak ties and a core of strong ties is a distinctive relational capability, one that provides fertile ground for leading firms in interfirm networks to gain competitive advantages whose sustainability is primarily based on the dynamic innovative capability resulting from leveraging a dual network architecture.

This study is aimed at contributing to theory building in the field of interfirm networks. The plausibility of the propositions presented in the preceding section has been partly established in the empirical research analyzed here. Testing and refinement await future research. Focusing on the different impact that strong dyadic ties, a strong ties network, and a dual network exert on the lead firm's innovative capability, I have advanced a cross-level preliminary model to explain why and how independent dyad- and network-level variables exert a causal influence on a dependent firm-level variable. Conversely, the antecedents of different network architectures were beyond the scope of this paper. However, my fieldwork suggests that the three alliance networks and their structures co-evolved with both environmental conditions and the overall strategies of their leading actors. Future studies will have to focus on such co-evolution to shed light on the exogenous and endogenous preconditions underlying the two archetypical network architectures discussed here. This may help explain why and how, as happened in my three cases, suboptimal network architectures can temporarily overwhelm more beneficial ones.

Some caveats may be in order, given that my arguments emerge from a limited number of case studies. Moreover, whereas the theoretical and

practical relevance of strategic network management asks for research in the field of relational capabilities, the case study might not be considered the most appropriate research strategy. However, following Eisenhardt (1989), I believe that the relative lack of empirical research on the topic justifies my methodological choice, while the multiple-case comparative approach adopted here contributes to increase the robustness of my findings and propositions.

Practicing managers and entrepreneurs should consider that strategic networks can provide firms with tangible and intangible resources needed to compete. Specifically, the research in this paper illustrates that, where the capability to innovate repeatedly is a prerequisite for competing successfully, firms benefit from business ideas in which systematic connections to innovation sources beyond the organization's boundaries are distinctive components from the very outset.

The three cases also offer prescriptions for strategic network maneuvering. Albeit strong ties yield substantial benefits, the lead firm may find itself closed in an inwardly focused network. Instead, adopting a dual network architecture allows the lead firm to rely on a narrow core of long-lasting, repeated, trust-based relationships with similar partners for exploitation purposes while at the same time exploring more distant knowledge areas, different organizational routines, and new markets through a large periphery of diverse, weak relationships. Thus, leveraging a dual network allows the lead firm to tackle the present at the same time as it paves the way for the future, and to avoid inertia by staying flexible toward innovative technologies, heterogeneous partners, and new market trends. The two parts of a dual network have to be managed in different ways, however. Therefore, studying the distinctive organizational routines that undergird strategic management of a dual network's core and periphery is a compelling avenue for further research.

I conclude by suggesting some other important aspects of this paper. First, I have advanced an operationalization of tie strength that, although specifically focused on interorganizational ties, takes account of the linkages between interorganizational and interpersonal relationships. Second, I have shown that simultaneous and explicit consideration of multiple levels of analysis, and 'dialogue' between research on different levels,

can enrich our explanations of intrinsically cross-level (inter)organizational phenomena. Using the lead firm's innovative capability as my outcome variable, I have first analyzed the strengths of strong dyadic interfirm ties. Then, exploring the linkages between the dyad level and the network level has allowed me to discuss why and how the strengths of strong ties can be offset by the pitfalls of a strong ties network or, conversely, reinforced by the advantages of a dual network. Thus, besides providing additional support for Granovetter's (1973) strength-of-weak-ties argument, this study adds that, when the lead firm develops the relational capability to integrate strong and weak ties within the same network architecture, the strengths of weak ties counteract the weaknesses of a strong ties network, and thus the strengths of a dual network emerge.

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