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Social Networks: Antecedents and Consequences

Social Networks

Chair: **Gianluca Carnabuci**; U. of Lugano;

Search Terms: Networks , Social Capital , Trust

OMT: **Enacting Embeddedness: How Managerial Interpretations Influence Advice Network Formation**

Author: **Ebony N. Bridwell-Mitchell**; Brown U.;
Author: **Theresa K Lant**; Pace U.;

It has become increasingly important to understand how managers' embeddedness in social networks has consequences for strategic decision making. Given this, it is also important to understand how managers become embedded in particular networks. The research herein addresses this question by examining the formation of managerial advice networks. Specifically, the work takes a cognitive perspective on social networks and strategic decision making to explore how managers' interpretations of organizational issues determine which contacts are solicited for advice. The results from a set of hierarchical linear models suggest that managers who interpret issues through a strategic frame solicit contacts perceived to be accessible, expert, and resource endowed. Managers who interpret issues through a political frame solicit contacts perceived to be trusted and influential. Given the apparent effects of managerial cognition on the composition of advice networks, we refer to the broader phenomenon as network enactment and discuss its implications for future research.

Search Terms: Network Formation , Issue Framing , Managerial Cognition

Paper is Available: View/Download

Supplementary Information: None

OMT: **Between Self-Organizing and Accelerating Networks: Untangling Strategic Networks Cognitive Dynamics**

Author: **Gabriella Levanti**; U. of Palermo;
Author: **Luigi Cuccia**; U. of Palermo;
Author: **Umberto La Commare**; U. of Palermo;

This paper aims to detect the crucial determinants and processes that shape the emergence and evolution of interfirm network cognitive morphology. We pinpoint three relatively distinct but coexistent levels which define the fundamental structure of the network: the microsystemic (or the single firm) level; the mesosystemic (or the groups of firms within the network) level; and the macrosystemic (or the overarching network) level. Then, we integrate the complex system perspective (Morin, 1977; Prigogine & Stengers, 1984; Anderson, 1999) applied to networks with studies regarding theoretical models that elucidate network structuring and dynamics cultivated in the new "science of networks" (Barabási, 2002; Watts, 2003) in such a way to typify the mesosystemic level as an accelerating network and the macrosystemic level as a self-organizing network. Finally, we represent multilevel network cognitive dynamics by means of a three-level cognitive shape that we term 'network cognitive domain' and dissect the correspondent multilevel governance scope of the network cognitive sub-domains.

Search Terms: network multilevel governance , network cognitive dynamics , cognitive domain

Paper is Available: View/Download

Supplementary Information: None

OMT: **The (Non)Sustainability of Brokerage: A Longitudinal Study of Brokered Triads in Innovation Networks**
Author: **Francisco Polidoro**; U. of Texas, Austin;
Author: **Jonathan Sims**; U. of Texas, Austin;

Research has shown that brokerage – direct ties to collaborators who themselves do not have a direct tie to each other – produces informational benefits that enhance the ability of individuals occupying brokerage positions to find new knowledge combinations. We argue and empirically demonstrate that repeated brokerage signals to brokered collaborators opportunities to recombine knowledge, thereby increasing their propensity to form a direct tie to each other. While prior literature has highlighted the benefits of brokerage, we emphasize that brokerage benefits may be non-sustainable, given that brokers, by seeking those benefits, contribute to the closure of brokered relationships.

Search Terms: None

Paper is NOT Available: Please contact the author(s).

Supplementary Information: None

OMT: **Strategic Flexibility and Change: The Impact of Social Networks.**
Author: **Virginia Fernández**; U. de Granada;
Author: **María del Mar Fuentes**; U. Granada;
Author: **ANA MARIA BOJICA**; U. of Granada;
Author: **Rodrigo Martín-Rojas**; U. of Granada.;

This paper seeks to examine external managerial social networks and to explain how the involvement in these networks influences strategic flexibility. It also studies whether this relationship is affected when the organization is involved in a process of strategic change. The data were gathered from surveys completed by the managers of 203 Spanish firms. The methodology used is regression analysis. We observe that external social networks affect strategic flexibility positively and these effects vary if the organization is involved in a process of strategic change. In this case, the structure of the networks and the level of strategic flexibility change.

Search Terms: External social networks , Strategic flexibility , Strategic change

Paper is Available: View/Download

Supplementary Information: None

OMT: **My Brother's Keeper: Patterns of Norm Violations in a Virtual World**
Author: **Magnus Torfason**; Columbia U.;

I examine the social structural patterns that are predictive of anti-normative violations, using data from a large multiplayer online game. In line with network closure theory, I analyze the relationship between local transitivity in network ties and antinormative behavior. I also explore how organizational identity mediates the effects of network structure on behavior. I find that the density of inter-organizational ties reduces the prevalence of anti-normative behavior, but that the density of intra-organizational ties increases it. The effects of intra- and inter-organizational network density are both moderated by the amount of experience that actors have of the game environment, albeit in different ways. Finally, in an analysis of network dynamics, I find evidence that individuals are more likely to experience the loss of ties following anti-normative violation.

Search Terms: None

Paper is Available: View/Download

Supplementary Information: None

Between Self-Organizing and Accelerating Networks: Untangling Strategic Networks Cognitive Dynamics

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BETWEEN SELF-ORGANIZING AND ACCELERATING NETWORKS:UNTANGLING STRATEGIC NETWORKS COGNITIVE DYNAMICS

Abstract. This paper aims to detect the crucial determinants and processes that shape the emergence and evolution of interfirm network cognitive morphology. We pinpoint three relatively distinct but coexistent levels which define the fundamental structure of the network: the microsystemic (or the single firm) level; the mesosystemic (or the groups of firms within the network) level; and the macrosystemic (or the overarching network) level. Then, we integrate the complex system perspective (Anderson, 1999) applied to networks with studies regarding theoretical models that elucidate network structuring and dynamics cultivated in the new "science of networks" (Barabási, 2002; Watts, 2003) in such a way to typify the mesosystemic level as an accelerating network and the macrosystemic level as a self-organizing network. Finally, we represent multilevel network cognitive dynamics by means of a three-level cognitive shape that we term 'network cognitive domain' and dissect the correspondent multilevel governance scope of the network cognitive sub-domains.

Introduction

In recent times, strategic interfirm networks have received a great deal of attention in the fields of strategic management and organization studies (Rowley & Baum, 2008). Such hastily escalating interest mainly depends on the strategic opportunities of knowledge exploration and exploitation that firms participating in interorganizational networks are able to recognize and capture (Powell, Koput & Smith-Doerr, 1996; Nooteboom, 2004; Schilling & Phelps, 2007). Interestingly, networked firm capacity to seize knowledge exploration and exploitation opportunities has

encouraged strategic management investigation to focus research efforts on the sources of competitive advantage that reside at the network level.

As sufficiently known, the network perspective in organization and management studies is mainly grounded in the tenets of social network analysis (Wasserman & Faust, 1994). Such studies have significantly contributed to move away from the mainstream economics-rooted individualist and atomistic behavioral assumptions and explanations that consider individual decisions and exchange as independent to one another, thereby leading toward a more relational and contextual view, which fruitfully extends the boundaries of strategic investigation to the intricate web of relationships in which firms are embedded (Gulati, Nohria & Zaheer, 2000). Notwithstanding that, the network perspective has shown the tendency not only to adopt an approach that is static in essence (Ahuja, Soda & Zaheer, 2007), but also to focus primarily on network structure (rather than on network processes) and on its influence on firm behavior and performance (McEvily & Zaheer, 1999; Ahuja, 2000; Rowley, Behrens & Krackhardt, 2000; Gulati, 2007). More in detail, interfirm networks (i.e., tangled/complex webs of linkages spanning and interconnecting a variety of idiosyncratic firms and other organizations within and across industries) serve as conduits through which information, knowledge and other resources flows and reputations are signaled (Poldony, 2001; Owen-Smith & Powell, 2004). Accordingly, the network structure and the firm positions within it determine, on the one hand, which firm will have access to and control over the so-called 'network resources' (Gulati, 1999) flowing through the network pipes. On the other hand, they guide what firms are able to signal in an appropriate way their feature as reliable and valuable partners. It is worth mentioning that the network perspective typically sees network structure and positions as exogenously determined, while paying little attention to the role that the single firms may play in shaping local network structures through the establishment, maintenance and dissolution of strategic relationships, as

well as how network positions are created and change over time (Rowley & Baum, 2008). Consequently, whereas the network perspective offers an incomplete understanding of how network morphology emerge and evolve over time, it also supplies a rather myopic view that the occurrence of network evolutionary dynamics can be a source of competitive advantage for (both) the single firms participating to the network and the network per se.

Lately, an increasing number of scholars have pointed out that a more satisfactory comprehension of the network-based determinants of competitive advantage can be achieved solely by moving beyond static conceptions of interfirm networks and of their effects and by advancing more dynamic views. Accordingly, it becomes of interest the identification and analysis of: i) the main forces that drive the emergence and evolution of network structure; ii) the "rules" and processes underlying the genesis and the dynamics of network structuring over time.

This paper aims to detect the aforementioned crucial determinants and processes that shape the emergence and evolution of network cognitive morphology. In order to turn out such conceptual contribution, we use the holistic and multilevel logic provided by the complex system perspective (Anderson, 1999) applied to networks and couple it to recent models that elucidate network structuring and dynamics and that have been cultivated in the new "science of networks" (Barabási, 2002; Watts, 2003).

We proceed by symbolizing our investigation path in three successive logical steps. Building on the interpretative and analytical framework sketched in Dagnino, Levanti and Mocciaro Li Destri (2008), we first represent the strategic network as a distinct conceptual macro-category that, by embracing and interconnecting a variety of idiosyncratic firms, originates a complex dynamic system of knowledge and capabilities. This interpretive framework enables to pinpoint three relatively distinct, but nonetheless complementary and coexistent levels, which define the fundamental structure of the network: the microsystemic (or the single firm) level; the

mesosystemic (or the groups of firms within the network) level; and the macrosystemic (or the overarching network) level. Each of these levels is capable to contribute in a unique and idiosyncratic way to networks dynamics, thanks to its specific structural and cognitive properties. Accordingly, the genesis and evolutionary pathway of the interfirm network stem from the cognitive dynamics occurring at each one of the three levels and lay in the interactions that inescapably arise (in part intentionally and in part spontaneously) among the levels.

Second, we integrate such framework with the complex system perspective and cognate studies regarding theoretical models that explain the structuring and dynamics of complex systems elaborated in the so-called new "science of networks". More in detail, networks and complex systems have attracted a profusion of recent inter- and intra-disciplinary research. From physics and computer science to biology and the social sciences, quite surprisingly scholars have found that a great variety of systems can be represented as networks and that these networks exhibit common proprieties and follow similar evolutionary path. As a consequence, network research has identified a few basic network models that can be applied to a variety of different network typologies; i.e., physical networks, biological networks, social networks, business networks and so on. The two models that in the context of this study are of interest to us have been labeled accelerating model and self-organizing model. In particular, on the ground of the hints provided by network system dynamics, while we acknowledge that the microsystemic level does not exhibit a more dominant category of connections, we typify the mesosystemic level as an accelerating network and the macrosystemic level as a self-organizing network.

Third, the integration of the analytic framework that looks at interfirm networks as complex dynamic systems of knowledge and capabilities with the hints originating from studies that consider network structure and dynamics through the vantage view supplied by the science of networks allows us to represent and capture the main determinants and processes underlying

the genesis and evolution of the network structure and, as well, as to appreciate the cognitive bases and consequences of network morphology**.** On the ground of these theoretical foundations, we represent the network's cognitive morphology by means of a three-level cognitive shape that we collectively term network cognitive domain and dissect the correspondent multilevel governance of the network cognitive domain.

The remainder of this paper is organized as follows. Drawing on previous network-related work, the second section depicts the network as a three-level complex dynamic system of knowledge and capabilities. In the third section, we leverage the contributions at the crossroads of investigation in networks and complex science to epitomize, respectively, mesosystemic level network dynamics as an accelerating network and macrosystemic level network dynamics as a self-organizing network. With the aim of analyzing the cognitive antecedents and consequences of network knowledge evolution, the fourth section sketches the contours of the network cognitive domain by allowing for its multilevel governance. In the fifth and closing section, we discuss some significant network-related cognitive upshots that stem from the conceptual underpinnings that we have laid down in the previous parts and eventually, point out at the limitations of the study and marshal a few conclusions.

A Multilevel Approach to Interorganizational Networks: The Interfirm Network as a Complex Dynamic System of Knowledge and Capabilities

In this paper, we extend the interpretative analytic framework that portraits interfirm networks as complex dynamic systems of knowledge and capabilities (Dagnino et al., 2008) integrating it with the implications of studies concerning theoretical and mathematical models, which scrutinize network morphology and the various dynamic rules that networks are expected

to follow in their evolution. From a methodological vantage point, the possibility to integrate these two bodies of research to achieve a more adequate representation and interpretation of interfirm networks dynamics rests in the consideration that ultimately both perspectives are firmly grounded in complexity theory (Gleick, 1987; Kauffman, 1993; Casti, 1995).

In the footsteps of previous work, complex systems theory is used as an interpretative backbone (Dagnino et al., 2008) than enables scholars to integrate and extend the concepts of the knowledge-based theory of the firm (Nonaka, Toyama & Nagata, 2000; Nonaka & Toyama, 2002) and the strategic network perspective (Gulati, 1999, 2007; McEvily & Zaheer, 1999, Gulati et al., 2000). As a result, we develop a speculative framework that is able to embrace both the firm-based and the network-based determinants of competitive advantage as well as to unveil the *multilevel* structure of interfirm networks.

More in detail, the above mentioned framework considers the interfirm network as a distinct conceptual macro-category that, embracing and interconnecting a variety of firms (each of them endowed with an idiosyncratic and valuable set of knowledge and capabilities), injects new lymph to a complex and dynamic system of knowledge and capabilities. The critical driving force that triggers single participating firms and the whole system is the search for rents. This specific search is accomplished thanks to a twofold strategy that rests on the creation of new knowledge and the amplification of the value of the existing one (March, 1991; Moran & Ghoshal, 1999; Gupta, Smith & Shalley, 2006). Accordingly, firms join the strategic network and interact with other networked firms in order to gain access to superior economic and cognitive opportunities. Over time, interfirm interactions drive to the emergence of a tangled composite structure (Kontopoulos, 1993; McKelvey, 1997). Within this cohesive and *connective* network structure, it is possible to identify three relatively distinct, but nonetheless complementary and coexisting, levels of analysis: 1) the *microsystemic level*, which concerns the single firms in the

network; 2) the *mesosystemic level*, which refers to the various groups of firms that maintain particularly strong and intense relationships vis-à-vis those held by the other firms that belong to the network; 3) the *macrosystemic level*, which concerns the network system as a whole; it is namely the single overarching set of relationships that embraces and connects, by means of weak ties, all the different firms and groups of firms participating in the network.

Each of the three analytical levels reported above displays distinctive relational characteristics that support the accomplishment of different semi-autonomous cognitive processes. Pursuing specific goals of knowledge exploitation and exploration, in fact each level exhibits a semi-autonomous evolutionary pathway (see Table 1). At the same time, the three systemic levels interact with each other and *coevolve* through unremitting *mutual* adaptations and adaptations to relevant changes that occur in the external environment (Anderson, 1999; Lewin & Volberda, 1999).

[Insert Table 1 about here]

In the following sub-sections, we proceed to emphasize the main relational characteristics and cognitive processes that distinguish the three systemic levels.

The microsystemic level

At the microsystemic level, each firm undertakes semi-autonomous processes that are aimed to produce new knowledge and to deploy the existing one both internally developed and produced at the meso and the macrosystemic levels, and absorbed at the microsystemic level. The capability of a single participating firm to take advantage of the cognitive assets residing within the higher network analytical levels is crucially related to its capabilities to pick up, absorb and integrate these assets with the internal one (Cohen & Levinthal, 1990; Grant, 1996). More in

detail, these capabilities strongly depend on the level of prior related knowledge (Lane & Lubatkin, 1998; Zahra & George, 2002), the past network structure and positions (Gulati, 2007; Soda & Zaheer, 2009), the existence of a middle or low cognitive distance between the learner and the knowledge source (Nooteboom, 2004), a suitable action of the so-called boundary spanners and gatekeepers (Ring & van de Ven 1994), as well as the creation of a dedicated alliance function and structure inside the firm (Kale, Dyer & Singh, 2001). Accordingly, the single firm belonging to the network is intended to be a complex subsystem per se. This means that it is made of a set of semiautonomous components (i.e., operating units, teams, and individuals) that work together. A mix of strong and weak ties typically connects together these components.

Interestingly, a number of authors in the management and organization literature, both adopting a relational (or dyadic) perspective (Larson, 1992; Dyer e Singh, 1998) and a network perspective (Gulati & Gargiulo 1999; Gulati et al., 2000), focus their studies on the microsystemic level. These authors mainly analyze how the context in which networked firms are embedded influences their strategic decisions, behaviors and performances. More in detail, a relevant research stream draws attention to firms that display critical roles inside the interfirm network as they are able to coordinate, direct, influence and manage the other network members. Such firms are termed in a variety of parsimonious manners, such as hub firms (Jarrillo, 1988), focal firm (Gulati, 1999; McEvily & Zaheer, 1999; Gulati et al., 2000), key actors (Knoke, 1994), triggering entities (Browning, Beyer & Shelter, 1995), strategic centers (Lorenzoni & Baden-Fuller, 1995), network orchestrators (Hinterhuber, 2002; Dhanaraj & Parkhe, 2006), and so on.

Additionally, other studies scrutinize the roles played by intermediate (or semi-peripheral) firms. The works mentioned above underscore that firms occupying intermediate positions within the interfirm network frequently act as technological or knowledge gatekeepers (Hargadon, 1998;

Giuliani & Bell, 2005) as well as they tend to develop superior creativity capabilities (Uzzi & Spiro, 2005; Cattani & Ferriani, 2008).

The mesosystemic level

At the mesosystemic level, an array of firm groups mainly connected by strong ties of interactions cooperate in order to jointly accomplish specific and definite objectives of learning, knowledge sharing and transfer as well as knowledge creation. The strong ties are realized through the establishment of strategic alliances, such as joint ventures, projects of product/technology joint development, R&D programs, consortia and associations of R&S, production and distribution, and so on. Within each group, repeated confrontations and interactions among the cooperating firms generate over time specific shared contexts that exhibit high mutual commitment, confidence, trust (Gulati, 2007) and low cognitive distance (Nooteboom, 2004) among them. These conditions allow more rapid confrontation and comprehension among the firms belonging to the group, as well as they curb the risk of opportunistic behaviors and promote open-ended sharing of valuable (tacit and explicit) knowledge. Consequently, at the mesosystemic level, barriers to tacit, complex and idiosyncratic knowledge transfer are swept away and concurrently smoother and faster processes of knowledge sharing and knowledge co-development take place (Uzzi, 1997; Hansen, 1999; Dyer & Hatch, 2006).

The management and governance of the strong ties of interactions that support the achievement of efficient, effective and timely processes of knowledge transfer and creation within each group of firms involve conveying consistent efforts in terms of commitment and time required, as well as the investment of a significant amount of (financial and human) resources. Accordingly, it is possible to maintain that, on the one hand, the connectivity level of the groups

of firms is considered a performance indicator as it permits to assess their capability to generate superior economic and cognitive opportunities. On the other hand, the establishment and the governance of strong ties are expensive and, thus, are subject to a careful analysis and assessment of the costs and benefits they entail.

The macrosystemic level

At the macrosystemic level, heterogeneous and specialized firms and different groups of firms are mostly connected by means of weak ties. Weak ties are flexible, relatively inexpensive and frequently informal. As such, they do not require ties-specific investment and, sometimes, emerge spontaneously as a result of social and trade relationships among individuals or firms that pursue a wide array of purposes (Granovetter, 1973). Weak ties consist in a variety of relationships such as interpersonal links among the employees, entrepreneurs and executives of the firms participating in the network, arm's length buyer-supplier relationships, competitive relations, connections with endorsing entities (such as investment banks and venture capital firms), ties with prior strategic partners, indirect links which occur through common third partners, trade association memberships, forums and conferences that aim to sketch the road map of the future evolution of the cognitive domains in which the network operates, and so on.

Thanks to the aforementioned characteristics, weak ties are able to link at the macrosystemic level a wide number of firms and groups of firms, endowed with idiosyncratic and specialized sets of resources, knowledge and capabilities. As a consequence, this level displays significant contents of variety and variability of the knowledge and capabilities that reside within it. Additionally, firms and groups involved at the macrosystemic level share idiosyncratic knowledge base and specific common language concerning the competitive and technologic domain in which the network operates. As a consequence, there is a partial overlapping among

the different knowledge bases residing in the macrosystemic level that smoothes the reciprocal understanding of the participating firms and groups. By means of such peculiarities, the macrosystemic level allows the accomplishment of rapid and relatively inexpensive processes of information circulation, brokerage, transfer of explicit and general knowledge among networked firms, as well as to timely signal potential availability of valuable knowledge pockets scattered throughout the network (Burt, 1992, 2005; Gargiulo & Benassi, 2000).

Self-organizing and Accelerating Networks: Navigating the Contribution of the New Science of Networks to Typifying Network Dynamics

In order to identify the main (endogenous and exogenous) determinants and processes underlying the genesis and dynamics of the interfirm network structure, we suggest that it is fruitful to integrate the multilevel interorganizational network framework depicted earlier with the hints of studies elaborated under the label of the new "science of networks" (Barabási, 2002; Watts, 2003). In particular, we distinguish two different structural dynamic behaviors, respectfully epitomizing *accelerating* networks and *self-organizing* networks, which guide network dynamics. More in particular, we maintain that the mesosystemic level displays an accelerating evolutionary behavior and the macrosystemic level exhibits a self-organizing evolutionary behavior. While the mesosystemic and the macrosystemic levels display a clear-cut structural evolutionary path, as concerns the microsystemic level we need to be more cautious to pinpoint specific behavior that typifies its structural evolutionary path. We discuss why it is so in the paragraphs that follow.

Whilst in the last decades the emphasis on firm networks has grown exponentially in organization and management literatures, various scholars spreading out from different scientific

fields have devoted notable consideration to empirically map and analyze the structure and dynamics of a range of technological, social and biological systems. Leveraging the study of real world systems depicted in network fashion, and focusing on both empirical and conceptual problems, these researchers have ended up detecting recurrent static and dynamic features of network topology that are not graspable by the hypothesized characteristics of the pure mathematical graph models, such as the random one (Erdős & Rényi, 1959). While it is acknowledged that there are intrinsic differences in the micro-relational constituent properties of networks, several kinds of complex networks typically show unplanned and a-centric evolutionary paths, resulting in: i) *static structural* characteristics familiar to the small world network hypothesis (Watts, 2003), in which the network diameter, or the mean of the minimal path lengths between nodes, is scaled down vis-à-vis the entire number of nodes belonging the network; and ii) *topological dynamic* features typical of scale free networks (Barabási & Albert, 1999; Barabási, 2002), that exhibit little change in their network structure and statistics as they grow, for example accounting for the distribution of the connections per node.

The microsystemic level. As noted above, the single firm participating in the network is a complex subsystem made up of several kinds of components (i.e., operating units, teams, individuals and resources). These components interact with each other by way of a mix of strong and weak ties, which are driven by a wide array of goals and dynamics. The mesosystemic and macrosystemic levels are complex subsystem as well. Whereas at the two latter network levels, it is possible to single out a category of ties that synthesizes the prevalent qualities of the connections, the microsystemic level does not exhibit a more dominant category of connections. Accordingly, we need to be cautious in pointing out a specific distinctive behavior that portrays the structural evolutionary path of the microsystemic level.

The mesosystemic level dynamics as an accelerating network

The mesosystemic level consists in functionally organized groups of firms, whose activities are grounded on the jointly accomplishment of coordinated and integrated cognitive processes of knowledge creation and sharing. In order to achieve the coordination and integration required to support these processes within the different groups, the participating firms interact mainly by means of strong ties. Although such ties are typically driven by economic incentives associated with superior cognitive opportunities, at the same time, they entail costly cooperative efforts and commitments.

The global connectivity of each group, consisting of N nodes (or firms), can be articulated as $C = L / L_{MAX}$, where L is the number of connections existing between the N firms, and $L_{MAX} = N*(N-1)/2$ represents the maximum number of links allowed, that approximately scales as the square of N. The connectivity (or density) of the mesosystemic level measures its integration grade. More specifically, an increase of density involves a growth of group integration that tendentially allows smoother and faster cognitive processes within it. Accordingly, density degree is a performance parameter of the mesosystemic level. Such connectivity changes as a result of the establishment of new links among firms participating in the group, the acceptance of new firms, as well as the breakdown of existing links (see Figure 1). For instance, in case of group expansion aiming to maintain the global connectivity unvaried, the number of new cooperative strong and costly ties has to increase more than linearly along with the number of new entering firms. Indeed, whereas mesolevel connectivity tends to decrease quadratically with firms number, the integration of new firms structurally requires an accelerating number of new connections. The acceleration connection requirement entails amplification in integration and coordination costs (Mattick & Gagen, 2005).

[Insert Figure 1 about here]

Accordingly, it is possible to affirm that the *structural accelerating behavior* exhibited by the mesosystemic level indicates that the evolution of this network level is constrained by the emergence of an upper limit on its size and complexity. This upper limit is associated with the costs determined by the need to increase the number of links in order to preserve (or enlarge) density and, ultimately, the performance of the level at hand. The economic incentives firms participating in the group receive are compared to the accelerating costs of new connections and integration. This state of affairs leads to the surfacing of a structural saturation point[1] beyond which the meso costs of integration exceed the advantages supplied by the meso level.

Once the mesosystemic level has achieved the edge of the structural saturation point, it displays two possible directions for future evolution: a) meso-network fragmentation that squarely reduce the number of expensive new connections needed by means of the exit of extant participant firms; b) drastic improvement in the need of meso-network governance that, providing operative and informative support by means of a dedicated set of integration and coordination mechanisms (Grandori & Soda, 1995), can alleviate commitments and costs of strong dyadic connections. We shall discuss more deeply the self-organizing dynamics of the macrosystemic level in the subsequent section.

The macrosystemic level dynamics as a self-organizing network

While the mesosystemic and macrosystemic levels are connected in many ways, the structural evolution pattern in the network macrosystemic level radically differs from the one displayed by the mesosystemic level. This occurs for the accelerating network behavior that we

[1] The structural saturation point is a point at which some capacity is at its fullest, or has reached the limit. At the saturation point, a specific 'structure' shows more costs than advantages deriving from its use.

have observed as being suitable to the mesosystemic level does not apply to actual the dynamics of the macrosystemic level.

In particular, while connections at the mesolevel observation ground are costly cooperative interactions, at the macrolevel network links consist mainly of weak and flexible interfirm relations. These relations do not entail remarkable link-specific investment since they often emerge spontaneously as a result of social and trade relationships among networked firms, their managers, entrepreneurs and employees. Macro level connections surface from both competitive and cooperative firm behaviors as they require low level of overlapping of knowledge pockets residing in the involved firms. This circumstance, on the one hand, allows for incidental, informal and free-wheeling sharing and circulation of ideas, of information and of explicit and general knowledge among the various and variable pool of networked firms. On the other hand, mostly in a spontaneous fashion, it generates over time continuous patterns of creation, renew and breakdown of weak and relatively inexpensive interfirm connections.

Consequently, we are in the position to maintain that the generation and evolution of network ties at the macrosystemic level are not circumscribed by the emergence of constraints associated with augmented interfirm integration and coordination costs as occurs at the meso level. In addition, link generation and evolution are characterized in essence by unplanned (Mintzberg & Waters, 1985) and a-centric dynamic properties. As a result of the action of the properties at hand, the structural evolution of the macrolevel is guided by *self-organizing* behavioral dynamics. For this reason, it is barely subject to requirements of conventional coordination mechanism-based network governance (for analytical discussion see next section). This means that, on the basis of the specific structural dynamic properties exhibited by the macrosystemic level, we are able to ascribe the behavior of self-organizing complex system to this level of analysis.

Untangling Networks Strategic Dynamics through Network Knowledge Evolution: The Multilevel Governance of the Network Cognitive Domain

On the ground of what we have earlier argued on the unique role of the three system levels identified as well as their specific structural dynamic behaviors, in this section we underscore the main forces that drive the structural evolution of the interfirm network. Actually, the structural evolution of the interfirm network is qualified in terms of *size* and *significance* of the connections that take place at multiple levels within the network.

In particular, according to this view network morphology in any given moment in time and point in space strongly depends on the key *cognitive* characteristics of the competitive and technological environment in which the network operates. These characteristics define the variety and complexity of the different knowledge bases and pieces of information that are expected to be spanned, combined and synthesized in order to shape the *network cognitive domain*, which is crucial to successfully compete in the current evolving business environment.

More in detail, the network cognitive domain is intended as the ’cognitive scope’ that the firms, the firm groups and the network as a whole must master to compete with success. The breath and complexity of the network cognitive scope (and therefore of the network cognitive domain) are related to the relevant traits that distinguish the competitive and technological dynamics of the industries in which the network is embedded. For instance, these relevant industry traits refer to: a) the dominant innovation types (architectural vs. generational); b) the latitude of innovation change (incremental vs. radical); c) the knowledge innovation effects (enhancing vs. destroying); d) the key characteristics of relevant knowledge (i.e., tacit vs. codified, stand-alone vs. dependent, general vs. specific, procedural vs. declarative).

The breath and complexity of the network cognitive scope underscore the need to span, confront and bring to a new synthesis several kinds of knowledge bases (that the wide range of firms and groups embedded in the network own or control). The accomplishment of the knowledge synthesizing processes requires contexts of interaction that are characterized by different relational conditions (Nonaka & Toyama, 2002). In more detail, the sharing of complex and tacit knowledge and the co-generation of new knowledge entail contexts essentially epitomized by strong and direct connections, whereas the transfer of information and explicit knowledge involves contexts typified by a broad array of weak and flexible (direct and indirect) relationships (Hansen, 1999; Reagans & McEvily, 2003). As a result, these processes take place at all the three different network levels and drive the emergence of a stratified architecture of the network cognitive domain. This stratified architecture is characterized by a three-level shape as follows: 1) the *micro-cognitive subdomain*, which comprise the prior idiosyncratic set of knowledge and capabilities that the single participating firm has developed and cumulated in the course of its existence; 2) the *meso-cognitive subdomain*, which includes the specific and deep sets of knowledge and capabilities that the firms belonging to the dense network groups share in definite moment in time and space. These knowledge sets originate from the accomplishment of joint activities and experience and are tacit and context-specific; 3) the *macro-cognitive subdomain*, which embraces the collective and wide sets of knowledge that *all* the firms and groups participating in the network share in definite moment in time and space. These knowledge sets stir up network-specific cognitive bedrock that supports the transfer of information and explicit and general knowledge among the heterogeneous network firms. Further, the joint cognitive bedrock ignites the timely signaling of knowledge potential trapped in pockets of local expertise scattered in the network macrosystemic level.

The dynamics that allows the surfacing and evolution of the specific three-tier architecture of network cognitive domain arises partly in an intentional fashion and partly in a spontaneous fashion owing to the network cognitive necessities (that are connected with the key cognitive environmental characteristics). More specifically, before the network is wholly formed, the sets of knowledge and capabilities residing in the interfirm relationships depend on the cognitive endowments owned or controlled by the single participating firms. Over time, these knowledge sets evolve according to the cognitive goals pursued and the strategic behaviors carried out at the different systemic levels. In particular, a *multilevel governance* process in the network cognitive domain drives the search for adequate fit between the network knowledge bundles and the critical cognitive characteristics of the competitive and technological environment in which the network operates. Network multilevel governance supports specific cognitive necessities fostering at the three systemic levels cognitive processes that are consistent with the evolving environmental conditions (i.e., transfer of information and explicit knowledge, sharing of tacit and complex knowledge, production of new knowledge, and signaling of valuable knowledge bases). Each systemic level exhibits distinctive relational characteristics earlier recalled that enable it to provide unique contribution to the cognitive processes which occur in the network. Accordingly, the multilevel governance of the network cognitive domain is able to drive network strategic dynamics and cognitive morphology over time (see Table 2).

[Insert Table 2 about here]

The micro level governance of the micro cognitive domain

At the microsystemic level, each single firm belonging to the network actively seeks to expand its abilities to grasp strategic opportunities related to knowledge exploitation and

exploration emerging throughout the network. As a result, the micro level governance aims to enhance: a) on the one hand, firm capabilities to absorb knowledge residing within the higher network levels (Lane & Lubatkin, 1998, Zahra & George, 2002, Giuliani & Bell, 2005); b) on the other hand, firm capabilities to manage interfirm relationships on the ground of its past network experience (Lorenzoni & Lipparini, 1999; Kale, Singh & Perlmutter, 2000; Gulati, 2007).

Moreover, microlevel governance processes involve the activity of monitoring and sensing weak signals coming from the network system per se (Teece, 2007). As the firm perceives valuable knowledge endowments residing within the firms and groups connected at the macrosystemic level, the micro governance picks out the more suitable way to activate the potentialities associated with their exploitation. There are two valuable options: i) transferring at the micro systemic level the relevant knowledge via merger or acquisition of the firms that own or control the knowledge sets or hiring their human resources; and ii) gaining access to the valuable cognitive resources by means of establishing strong interactions at the mesosystemic level with the firms that own or control these cognitive resources. For instance, Inkpen (2005, 2008), in his study of the joint ventures between General Motors (GM) and Toyota, named "New United Motor Manufacturing Inc." or NUMMI, underscores that GM was able to absorb and disseminate inside the firm the knowledge and competences related to the Toyota production system merely by means of complex and time-consuming interactions of its human resources in the NUMMI. More in detail, in the course of NUMMI collaboration, GM managers progressively acquired awareness of the actual benefits associated with NUMMI learning opportunities and were capable to overcome their initial skepticism towards lean manufacturing. Accordingly, they systematic implemented a multifaceted learning system consisting of set of knowledge transfer mechanisms purposely built to exploit the learning opportunities surfacing in the NUMMI context (such as, a specific advisor system, instrumental visits and plant tours, a technical liaison

office, and so on). As a result, GM achieved effective knowledge transfer outcomes as the improvement in manufacturing productivity and product quality (at GM) demonstrates.

The meso level governance of the meso cognitive domain

As illustrated in the second section, the critical contribution that the mesosystemic level supplies rests in overcoming the barrier to tacit, complex and idiosyncratic knowledge transfer and in achieving smoother and faster processes of knowledge sharing and knowledge co-generation among the firms participating in the network groups. In addition, since the establishment of strong ties of interaction is costly, the mesosystemic level exhibits *structural accelerating behavior* that imposes an upper limit to the size and complexity of this level. Such upper limit may be fine-tuned and surpassed by careful and well-considered governance of the mesosystemic level.

The governance of the mesosystemic level is mostly intentionally operated by means of processes of negotiation and confrontation among the firms participating to the meso level groups. Negotiation processes allow the firms in the meso level group, on the one hand, to settle specific joint objectives of learning, knowledge sharing and knowledge creation. On the other hand, they lead to the establishment of a mix of coordination and integration mechanisms through which is possible to support strong firm interaction. In particular, by leveraging the synergies and virtuous circles that reinforce each other the different coordination and integration mechanisms (Casciaro, 2003; Mellewigt, Madhok & Weibel, 2007), the meso governance process is able to alleviate the cost of strong network connections. This situation permits to unbind resources that can be assigned to the accomplishment of new cognitive and learning purposes. As a consequence, the renewal of existing ties and the activation of new connections at the mesosystemic level permit the upsurge of new cognitive processes that contribute to guarantee a

good match between the mesosystemic cognitive subdomain and the evolving competitive and technological conditions of the network environment.

For example, qualitative studies (Dyer & Nobeoka, 2000; Dagnino et. al., 2008), focusing on the network that binds Toyota with its first-tier suppliers in the Georgetown (Kentucky) plant, illustrate the wide array of different but interrelated interaction mechanisms and shared contexts (such as, consulting teams, the Toyota Supplier Support Center, learning teams, and so on) that Toyota implemented to coordinate and integrate in a *heterarchi*c way (Mintzberg, 1979; Kontopoulos, 1993) its semi-autonomous suppliers. By means of this intertwined bundle of mechanisms and contexts, Toyota was able reducing the cost related to dense and strong interaction and nurturing the availability of the single suppliers to openly share their valuable knowledge with other networked firms. In addition, the cognitive interaction at the mesosystem level among Toyota and its suppliers achieved over time independent viability (i.e., the mesosystem level reached high autonomy vis-à-vis the other two levels).

Mesosystemic level interactions by means of strong and dense ties amplify mutual understanding, confidence and familiarity among firms belonging to the various groups, as well as curb the risk of opportunistic behaviors. This situation in turn enables the achievement of superior processes of tacit and complex knowledge exploitation and exploration within interfirm groups. At the same time, strong ties often entail, on the one hand, the tendency to give way to processes of homophily leading to a decline in the variety of knowledge endowments of the interacting firms (Uzzi, 1997; Rowley et al., 2000;). On the other hand, they require costly meso-specific investments and generate structural persistence (Gulati, 2007; Soda e Zaheer, 2009). Over time, this state of affairs produces inertia and inward looking myopia (Levinthal & March, 1993; Afuah, 2000), which limit firm and network ability to sense the emergence of opportunities and threats connected to change in the external environmental and adapt to them.

The macro level governance of the macro cognitive domain

The analysis performed in the second section of this paper underscores that ties supporting interfirm relationship at the macro level are weak, relatively inexpensive, and often emerge spontaneously. As a result, the macrosystemic level embraces a considerable number of heterogeneous firms, which are endowed with idiosyncratic and valuable sets of knowledge and capabilities. It also exhibits structural self-organizing behavioral dynamics that turns out its structural evolution in pretty unplanned and a-centric fashion. Consequently, rather than being influenced by intentional managerially coordinated or controlled interfirm behaviors, the macro level governance processes are mainly emergent as they result from the spontaneous interrelations taking shape among the firms and groups participating in the network.

Accordingly, for the emergent and self-organizing nature of the macrosystemic level one could be induced to believe that governance is neither required nor tolerated at this relvant network level. Actually, macro level governance takes an inherently distinctive shape vis-à-vis mesolevel governance as it consists of general guidance or principles aimed to support the presence of significant content variety and variability in the knowledge endowments owned or controlled by the firms and groups participating in the network. Far from being focused on specific sets of predefined coordination mechanisms as occurred in the case of the meso level, macro level governance is expected to be highly contingent to varying network conditions and directed to combine cognitive heterogeneity within the network (at least until to a certain degree), thereby instilling clear-cut sense of flexibility and openness in the relevant network actors helpful to conveniently leverage the required cognitive distance. This circumstance contributes to countervail the risk that firms embedded in dense meso-level groups develop over time inward

looking myopia, which may restrict their ability to spot and seize current and future network cognitive opportunities (Capaldo, 2007; Schilling & Phelps, 2007).

In the course of time, the nested bundle of relationships which connect networked firms and groups by means of repeated direct ties as well as credible third-parties (Gulati, 2007; Uzzi & Spiro, 2005) drives the emergence of four main elements that characterize the macrosystemic level. These fundamental elements consist in: a) a general and widely spanned network-specific cognitive bedrock (i.e., the macrosystemic cognitive subdomain); b) a network-specific communication language; c) network identity; d) collective network vision.

The above mentioned elements are shared by *all* the firms and groups belonging to the network. Network identity and collective network vision foster interfirm motivation to cooperate and curtail the risks of opportunistic behaviors (Dyer & Nobeoka, 2000; Dyer & Hatch, 2006). The network-specific bedrock and the network-specific language operate as interfaces among network members allowing more rapid information circulation and timely signaling of valuable knowledge controlled by the single networked firms and groups.

In particular, network idiosyncratic communication language performs two distinct but interrelated functions within the macrosystemic level. First, it affects the *perception* of the single firms and groups belonging to the network since it organizes signals, information and knowledge into specific perceptual categories and provides a framework of reference for observing, interpreting and evaluating these elements. As a consequence, the firms and groups that share the network-specific language are able to filter out less important information and, as well, to assess and seize potential economic and cognitive opportunities associated with intra-network knowledge exchange and combination (Nahapiet & Ghoshal, 1998). Second, network-specific language is usually highly idiosyncratic as it typifies the firms and groups participating in the network. While network idiosyncratic language, on the one hand, constrains participating firms

behavior since the development of a network-specific language requires the accomplishment of a significant amount of network-related investments (Gulati, 2007; Soda & Zaheer, 2008), on the other hand, it circumscribes the possibility to possess the capabilities of grasping network cognitive opportunities to a definite set of firms within the network. This definite set of firms is made of those firms that, thanks to their worthwhile knowledge endowment, are regarded as (potential) strategic partners and are accepted within the interfirm network (Owen-Smith & Powell, 2004).

Network-specific language plays an essential role in supporting the development and enhancement of the cognitive dimension of *network-specific social capital* (Nahapiet & Ghoshal, 1998). The cognitive dimension of network-specific social capital lubricates mutual coordination and understanding among firms and groups participating in the network. In doing so, it contributes to generate conditions that support value creation within the network as it affects networked firm and group accessibility to valuable knowledge, capacity to perceive and see favorable cognitive opportunities, motivation and ability to grasp the perceived opportunities (Moran & Ghoshal, 1999).

Summing up, we are in the position to argue that the partly emergent and unintentional macro level governance processes are crucial to guarantee the whole network autonomy and flexibility of action, knowledge variety and variability, and the cognitive distance needed to explore and innovate. These conditions enable the network to hedge bets on the uncertainty concerning: a) what pieces of knowledge will be relevant in the future; b) which networked firms are expected to have such knowledge; c) which networked firms are going to survive providing direct or indirect access to the strategic network knowledge (Nooteboom, 2004). It follows that the governance of the macro level cognitive domain plays an unsubstitutable role when it

generates conditions that preserve and increase over time the value of the network cognitive domain vis-à-vis environmental dynamics.

For instance, Dagnino et al. (2008) illustrate the evolutionary dynamics that allowed STMicroelectronics to develop an intertwined web of heterogeneous firms mutually interacting by means of a blend of weak (at the macrosystemic level) and strong (at the mesosystemic level) ties. In particular, the perception of a common challenge (i.e., the difficulty of the so called '*game against nature'* associated with the miniaturization of the chips and the integration on a single die of entire systems with much functionality) initially spurred STMicroelectronics, its main customers and suppliers, other semiconductor industry manufacturers, leading universities and research institutions to cooperate. Over time, macro level network cooperation paved the way to the formation of a network-specific shared space at the macrosystemic level that consented to accomplish efficient, effective and rapid information and explicit knowledge transfer among the networked firms. The superior network cognitive processes were mostly due to the network-specific knowledge base and the network-specific language shared by all the participating firms. This condition supported flexible division of innovative work within the network that allowed all the firms embedded in it to capture the edge of the knowledge frontier in particular specialized activities.

Discussion

In this paper, we dig up to demarcate the inner foundation and processes that model the emergence and evolution of interorganizational network cognitive morphology. In particular, using a three-level cognitive shape that we labeled "network cognitive domain" and delving into the multilevel governance of the network cognitive domain, we have represented the crucial determinants affecting dynamic change in network's cognitive morphology. We did it by

coupling the lenses of complex systems (Anderson, 1999) with studies concerning conceptual approaches that explain network structuring and dynamics that have been lately cultivated in the realm of the new "science of networks" (Barabási, 2002; Watts, 2003). This vantage stance has allowed us to depict the network as a multiple level cognitive structure that correspondingly requires multiple governance levels. The kind of investigation at hand appears of significant interest to management scholars since the frontiers of actual network scrutiny rest essentially in multiple attempts to unleash suitable, appealing and more dynamic explanations of network emergence and evolution (Ahuja et al., 2007).

On the basis of the contentions outspread from the thorough conceptual investigation of network knowledge heretofore performed, in this section we insinuate few relevant hints that are related to four issues in network cognitive inquiry: network multilevel interactions, the role of networks' central and peripheral poles, the cognitive role, cognitive paths and cognitive positions of firms and groups participating in an network, and eventually the origin and development of network cognitive capabilities.

Network multilevel interaction. Since each of the three systemic levels (micro, meso and macro) is typified by specific relational characteristics, it is able to perform distinct but connected cognitive processes as well as semi-autonomous evolutionary paths. More specifically, the three systemic levels interact with each other and coevolve through mutual adaptations and adaptations to the evolving competitive and technological conditions external to the network as a whole (Anderson, 1999; Lewin & Volberda, 1999). The activation of information and knowledge flows (between and) across the systemic levels sparks off strategic interactions among the three layers. In fact, the pieces of knowledge created at the microsystemic and mesosystemic levels span each other thanks to the macrosystemic level. This circumstance allows the identification of favorable opportunities of knowledge transfer, sharing and combination throughout the network and,

ultimately, drives the accomplishment of the processes needed to grasp these cognitive opportunities. Consequently, we are in the position to affirm that interactions that arise (partly intentionally and partly spontaneously) among the three systemic levels (micro, meso and macro) activate a tangled bundle of cognitive processes within the network. This tangled bundle of cognitive processes is able to catch advantages associated with: i) *autonomy and creativity*. The autonomy and flexibility of action that the single firms have at the microsystemic level unleash creativity that nurtures firm ability to sense and seize knowledge opportunities surfacing throughout the network (Uzzi & Spiro, 2005). Further, autonomy and creativity affect firm ability, on the one hand, to govern the micro-cognitive subdomain. On the other hand, on the basis of firm relational capabilities, they contribute to the meso level governance alleviating the cost of strong connections and spurring the creation and the renew of ties at the mesosystemic level; ii) *local mesosystemic density*. Meso level strong and dense interactions support complex and tacit transfer and co-generation of new knowledge. By means of these processes, the specific and deep sets of knowledge and capabilities that constitute the meso cognitive subdomain are produced, preserved and enhanced; iii) *network global efficiency*. Network macro level weak and sparse connections provide for the requisite variety of the macro cognitive subdomain enabling a wide range of cognitive opportunities connected with intra-network knowledge exchange and combination (Schilling & Phelps, 2007).

These circumstances tend to fine-tune the network capacity to attain an adequate match between the network cognitive domain and the evolving competitive and technological characteristics of the environment in which the network is embedded. As a consequence, the whole network as well as the single firms and groups participating in it are able to generate and revive over time their competitive and cognitive advantages.

Central and peripheral poles. Complex interfirm networks typically display a structure characterized by central and peripheral poles. As firms with low cognitive distance (i.e., similar knowledge endowments) tend to be highly connected to one another (McPherson, Smith-Lovin & Cook, 2001), groups of firms come to gather inside the network. The firms belonging to the intra-network groups maintain particularly intense and frequent direct relationships vis-à-vis those held with the other networked firms. The strong and dense groups identify the network mesosystemic level. Each mesosystemic level group (or pole) controls an idiosyncratic set of knowledge that exhibits different value and abilities to contribute to the network cognitive potential. This situation drives the creation of: a) *central poles* that act as cognitive leader within the network thanks to their critical cognitive abilities; b) *peripheral poles* that operate as cognitive follower due to their lower cognitive abilities (Giuliani & Bell, 2005).

Network poles that, in a given moment in time and point in space, operate as distinctive 'cognitive leaders' inside the network as they are able to steer up the evolutionary dynamics of the network cognitive domain. Actually, on the basis of their knowledge endowments, central poles have the capacity and the power to affect the direction taken by network cognitive processes and, consequently, to shape knowledge development and accumulation in the three layers of the network cognitive domain. In addition, central poles influence the quality and the quantity of the interactions and connections arising in each of the three network systemic levels (micro, meso and macro) and, hence, they shape the evolution of the network structure. For instance, Giuliani and Bell (2005) provide evidence that the wine cluster in Colchagua Valley (Chile) displays a clear core-peripheral knowledge structure. The central pole is composed of firms that possess, on average, higher cluster absorptive capacity and wider/stronger knowledge base than the firm in the periphery. Accordingly, central firms are able to act as knowledge gatekeepers and knowledge sources as well as they are engaged in intra-cluster knowledge

diffusion processes. The cluster cognitive core is surrounded by a larger numbers of basically passive firms that, in a nonsystematic fashion, absorb pieces of knowledge from the core or seldom directly from external sources. This situation allows central firms to drive the overall technological and knowledge dynamism of the cluster as a whole. It is interesting to note that firm cognitive roles and positions seem to be unrelated to the physical location and the spatial propinquity of the firms in the cluster.

The former considerations allow us to underscore that, within the network, the ability of networked firms and groups to contribute to the network cognitive *potential* and to drive the dynamics of the network cognitive domain is strongly related to the value of the knowledge endowments they own and control in a definite lapse of time and space (that we may call 'network cognitive pre-history'). The value of knowledge endowment may change over time. Specifically, firms and groups can act in order the value of their knowledge sets vis-à-vis key cognitive environmental characteristics. Accordingly, firms and groups endeavor to develop superior knowledge sets; i.e., knowledge sets that better match with the opportunities and/or the threats connected to the evolving environmental conditions. The activity of knowledge enhancement rests in firm (and group) capacity to seize the opportunity provided by the self-organizing evolution and expansion of the network macrosystemic level. These expanding opportunities may be captured by means of the activation of cognitive processes at the microsystemic and the mesosystemic levels. The activation of cognitive processes at the microsystemic level allows the development of the knowledge sets that constitute the micro-cognitive subdomain. The activation of cognitive processes at the mesosystemic level requires the renewal of the existing strong connections within the dense meso groups or the establishment of new strong ties. Specifically, the thickening of meso level synergies is rooted in the ability of firms participating in the meso groups to take advantage from the accelerating evolutionary

behavior displayed by the mesosystemic level. In fact, we pinpoint at the firms that are able to reduce the cost of strong ties within the meso dense groups they participate into and to unbind resources that may be assigned to the accomplishment of new cognitive and learning purpose. This state of affairs increases firm meso level connectivity and, hence, the benefit that they reap from the mesosystemic level. Accordingly, peripheral firms that implement the above mentioned cognitive-enhancing activities may over time drive the emergence of new network central pole thereby rebalancing the power distribution inside the network.

Cognitive roles, cognitive paths and cognitive positions. On the basis of the knowledge endowments that they own or control, firms and groups participating in the network play different *cognitive roles*. More in detail, first within the network we may identify firms and groups that act as *knowledge brokers* among other networked firms and groups that have no direct ties (Hargadon, 1998). Bridging unconnected network members, these firms and groups provide access to knowledge entrapped (or ensnared) in pockets of local (firm or group) expertise (Burt, 2005; Uzzi & Spiro, 2005). Second, some firms and groups belonging to the network operate as *knowledge gatekeepers* vis-à-vis external environment. This means that they are able to spot and absorb valuable knowledge from the external environmental. Therefore, they constitute (actual or potential) access gates to extra-network knowledge (or knowledge external to the network). Third, since some networked firms and groups are available to transfer to the other networked firms and groups the knowledge they own and control, they perform the role of *knowledge sources*. Fourth and consequently, inside the network there are some firms and groups that play the role of *knowledge absorbers* from the other network members. These firms and groups have significant capacities to acquire useful knowledge owned and controlled by the other networked firms and groups and to apply the transferred knowledge at the microsystemic and the mesosystemic levels. Fifth and finally, some firms and groups participating in the network

function as knowledge *activators* of intra-network cognitive processes. This means that they are able to perceive network opportunities associated with knowledge exchange, sharing and combination among network members and, at the same time, to spur and stimulate the interest of the other networked firms and groups to accomplish these cognitive processes.

Bearing roles such as knowledge brokers, knowledge sources and knowledge activators, the networked firms and groups drive the activation of cognitive processes at the three systemic levels (micro, meso and macro). This in turn guides the *evolutionary path* of the network cognitive domain since the activation of the cognitive processes at the three systemic levels allows the development and the accumulation of the knowledge sets that are included in the three-tier cognitive subdomains (micro, meso and macro). In addition, firm and group activities affect their *cognitive position* inside the network. The single firm and the group cognitive position epitomizes the prominence that each of them play within the network. Network cognitive prominence of a single firm or group may be indirectly measured of means of distinct centrality indexes (i.e., in-degree centrality, out-degree centrality, betweenness centrality), as we assume that the establishment of intra-network relationships reflects and requires the ownership and control of adequate knowledge endowment[2].

Network cognitive capabilities. In our knowledge-based view of networks, interfirm networks are normally able to develop cognitive capabilities. Drawing on Helfat and Peteraf (2009), like organizational capabilities, cognitive capabilities may produce outputs (e.g., tacit knowledge accumulated in learning by doing processes) such as knowledge adding to the stock of knowledge resources. They are more than just cognitive potential and explicate, at least in part, the source of

[2]Centrality indexes take into consideration the amount of relationships in which the network actor is involved as recipient (in-degree centrality) or source (out-degree centrality) of the ties, as well as the extent to which the actor connects other pairs of actors that have no direct relations (betweenness centrality) (Wasserman and Faust, 1994).

firm heterogeneity and competitive advantage. As such, we regard network cognitive capabilities as idiosyncratic capabilities fundamentally residing in each of the three network cognitive levels that we have theorized in this study (micro, meso and macro) that are instrumental in seizing cognitive opportunities along network's evolutionary paths. We also look at them as important knowledge resource governance mechanisms that may intervene and favor the governance of network cognitive evolution with respect to the evolving features of the environments in which networks are embedded and active.

As illustrated in the previous section, the size and significance of each systemic level and of the associated cognitive subdomain basically depend on the key cognitive characteristics of the competitive and technological environment in which the network operates. Accordingly, within a network that operates in an industry epitomized by rapidly evolving knowledge bases and radical innovation flow, the critical determinants of competitive advantage are grounded in the network abilities to fostering continuous renewal of cognitive resources and to nurturing knowledge heterogeneity and creativity. Accordingly, since it pools a wide and evolving array of knowledge sets a critical role within the network is played by the macrosystemic level together with the microsystemic level in sensing and activating the economic and cognitive opportunities that are spread across the network.

Correspondingly, in a network embedded in a less turbulent environment characterized by incremental innovation flows, the key sources of competitive advantage are rooted on the network capacities to foster rapid knowledge exploitation and to produce new knowledge combining and integrating specialized and idiosyncratic knowledge bases. In this perspective, the mesosystemic level plays a dominant role within the network supporting deep and frequent interactions among firms. Simultaneously, the microsystemic level provides decisive contribution

to the network dynamics affecting the meso level governance, since it is able to alleviate the cost of strong ties thereby increasing the network meso level connectivity.

Also depending on the relative latitude of previously received cognitive capability endowment, on average we estimate that repeated network cognitive interaction at the three relevant levels come to support the development of network cognitive capabilities, while critical mass of actual cognitive capabilities are normally expected to reside more in network's central poles vis-à-vis peripheral poles (Giuliani & Bell, 2005). Nonetheless, networks' peripheral poles, seen as cognitive follower, especially at the mesosystemic level may play a role in sensing earlier the characteristics of newly forming environments and markets and therefore in developing the 'right' cognitive capabilities that will be valuable and precious in the of the next wave(s) of technology competition regime.

Limitations and Conclusion

As regards the limitations of this chapter we first raise the question, inherently inescapable in conceptual exploratory research such as this one, of the overall explicative power of issues originating from the investigative study of networks. In this regard, the use of a well-balanced mix of instruments and methodologies, characteristic of empirical analyses, could come to corroborate the relative strength of the arguments we have purported in this paper. The study therefore remains exploratory in essence. Second, while we have investigated the key relations between network cognitive dynamics and network governance, we have focused expressly on dynamics of various networks that were already formed and living, though not necessarily mature. In the vein of the budding strategic entrepreneurship research body, further scrutiny is therefore called to closely scrutinize network foundational and start up phases that seems of particular interest to fully grasp the different intriguing imaginative leaves of network inner

cognitive dynamics. Finally, this study is focused entirely on networks whose formation and evolution is fundamentally rooted on the desire to cooperate in the knowledge sharing and creation processes. Nonetheless, it ought to be emphasized that not all networks emerge and exist for knowledge-related purposes. Networks formed between venture capitalists, for example, appear to be based on risk sharing issues rather than knowledge sharing. The cognitive framework elaborated in this study is hence of little use in all those cases in which knowledge sharing is not the main underlying rational behind network formation and evolution.

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FIGURE 1

Three Evolving Networks: The Number of Links to Maintain or Increase the Connectivity Depends on the Network Starting Topology

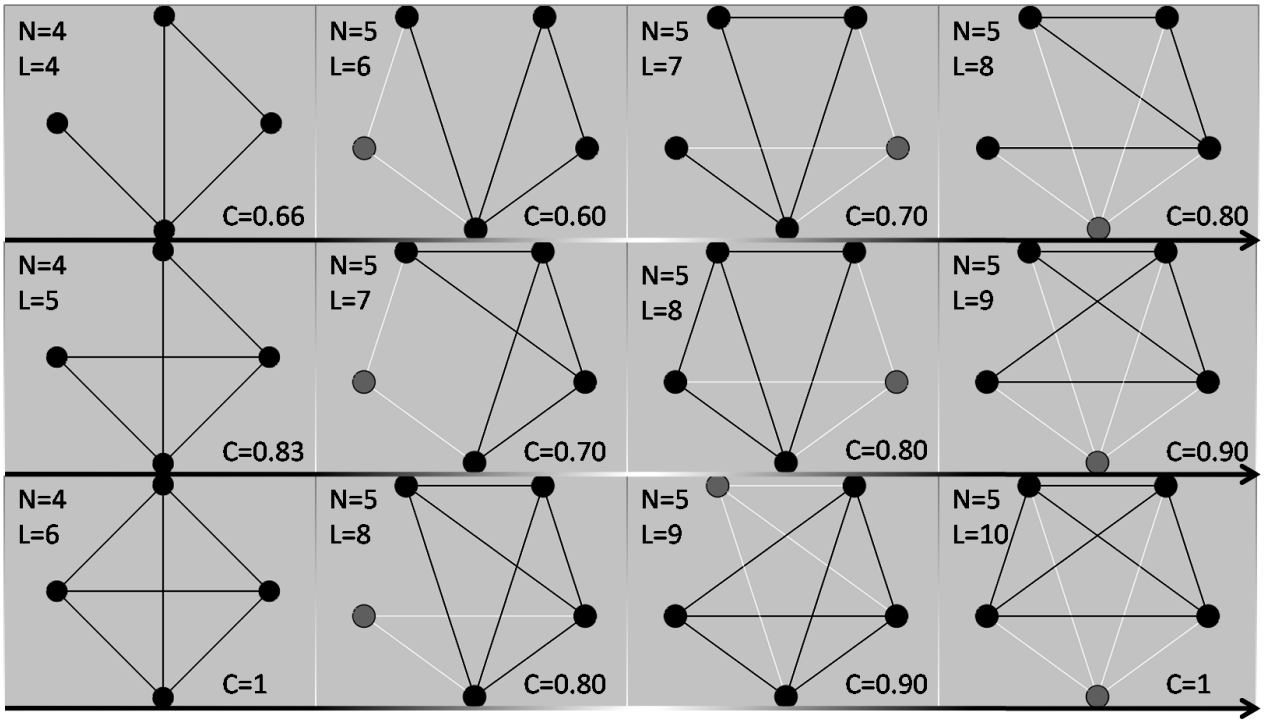

TABLE 1

The Main Features of the Three Levels of the Interfirm Network

	Microsystemic Level	**Mesosystemic Level**	**Macrosystemic Level**
Tie Typology	Mix of strong and weak ties	Prevalence of strong ties	Prevalence of weak ties
Tie Property	Bundle of hierarchical, cooperative and competitive ties	Typically cooperative	Competitive and cooperative
Tie Drivers	Mix of deliberate and spontaneous relations and interaction among operating units, teams, and individuals	Prevalence of deliberately programmed and implemented interfirm interactions	Prevalence of spontaneous incidental and informal interfirm relationships
Tie Antecedents	Economic and noneconomic incentives	Economic incentives	Economic and noneconomic incentives
Main Knowledge Characteristics	Knowledge idiosyncrasy	Knowledge specificity and depth	Knowledge heterogeneity and breadth
Topological Evolution	-	Upper limited	Tendentially not limited
Network Governance	Mostly deliberately carried on	Mostly planned and interactively operated	Mostly unplanned and emerging
Purpose of the Network Level	Knowledge exploitation and exploration	Complex and tacit knowledge sharing Knowledge co-generation	Information and explicit knowledge circulation Valuable knowledge pockets signaling

TABLE 2.

The Main Features of the Three Tiers Network Cognitive Domain

	Microsystemic Level	**Mesosystemic Level**	**Macrosystemic Level**
Characteristics of Knowledge Sets	Idiosyncratic knowledge sets owned and controlled by each single firm	Specific and deep knowledge sets shared by firms belonging to dense groups	General and wide knowledge sets shared by all networked firms and groups
Main Governance Drivers	Guidance of single firm	Processes of negotiation among the firms participating to the meso level groups	Spontaneous relations that allow the emergence of network-specific bedrock, network-specific language, network identity and collective network vision
Governance Goals	Enhance absorptive capabilities, relational capabilities and capabilities to sensing weak signals of the single firm	Alleviate the cost of strong meso connections Enhance mutual understanding and confidence within the groups Curb the risk of opportunistic behaviors inside the groups	Support knowledge variety and variability Counterbalance the risk of inward looking myopia