PART I

The Current State of Knowledge
2. Innovation networks in industry

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1. INTRODUCTION

It has become almost a cliché to argue that the behavior and performance of firms only can be understood fully by examining their social, technological, and exchange relationships with other economic agents. The image of atomistic agents competing for profits in impersonal markets has become increasingly inadequate in view of the explosion of inter-firm collaboration the past two to three decades, as well as the growing empirical evidence formally substantiating the influence of the social context in which firms are embedded on their conduct and performance (Gulati, 1998; Gulati et al., 2000).

Perhaps the most important aspect of the social context of an organization’s environment is its social network of external contacts. A social network can be defined as a set of nodes linked by a set of social relationships of a specified type (Gulati, 1998). It is argued that the kind of networks in which the firm is embedded and its position in these networks affect the firm’s behavior and performance. Reminiscent of the resource-based view of the firm – which emphasized the potential for enduring benefits to an organization from a collection of resources that is inimitable and not readily substitutable (Peteraf, 1993) – network scholars now argue that a firm’s network relationships can themselves create unique and non-substitutable value and allow access to the inimitable resources and capabilities of other firms.

In other words, networks bestow the firm with “network resources,” which are equivalent to the idea of “social capital” in an organizational setting (Gulati, 1999). The firm’s stock of relational or social capital – network resources emanating from prior relationships with other organizations – is argued to qualify as a resource. Other resources joining with relational or social capital are technical capital – capabilities to create new technologies, products, processes – and commercial capital – complementary assets required to commercialize new technologies and obtain rents (Kale et al., 2000). Each of these asset stocks adds value, is accumulated over time, and, most importantly, is difficult to trade across markets. As
such, each of these asset stocks becomes a potent, lasting source of competitive strength.

This chapter deals with the social context, the organizational aspects, and the strategic implications of inter-organizational networks for science, technology and innovation – or innovation networks, for short. Innovation networks, the complex webs of relationships among firms, universities, and other research organizations associated with generating and sharing knowledge relevant to technological innovation, are considered a major new feature of the contemporary economy. In the presence of technological development involving an ever larger array of product and process systems, subsystems, and components, no single firm can deploy all of the required core capabilities and complementary assets at a reasonable cost. In this context, a network can serve as a locus for innovation because, for any network member, it can provide timely access to external knowledge and resources that are otherwise unavailable, while also testing internal expertise and learning abilities. Linkages within innovation networks are very complex, involving not only diverse kinds of formal contracts, but also informal exchanges of knowledge, thus increasing opportunities for knowledge transmission.

Such developments have created a proliferation of literature trying to explain incentives and results. Several special issues and individual papers on alliances and networks have appeared in the past decade and a half in journals such as the *Academy of Management Journal* (edited by Osborn and Hagedoorn, 1997), *Organization Science* (edited by Koza and Lewin, 1998), *Organization Studies* (edited by Grandori, 1998), *International Studies of Management and Organizations* (edited by Ebers and Jarillo, 1998), *Strategic Management Journal* (edited by Gulati et al., 2000), and *Journal of Technology Transfer* (edited by Arvanitis and Vonortas, 2000). In addition, several research projects in Europe have dealt with aspects of network formation and knowledge communication, including two we are more familiar with (Caloghirou and Vonortas, 2000; Caloghirou et al., 2001). There have been also review articles, such as Gulati (1998, 1999), Oliver and Ebers (1998), and Hagedoorn et al. (2000), as well as numerous books such as Nohria and Eccles (1992), Nooteboom (1999) and Vonortas (1997) that have tried to map the literature on alliances and networks.

Three concepts/analytical propositions have enjoyed widespread support in this literature and guide the discussion in this chapter (Kogut, 2000; Nooteboom and Gilsing, 2004; Rowley et al., 2000):

1. The analysis of network influence on members’ strategy must pay attention to both issues of cognition (information, learning) and governance.
2. Network structure is an emergent phenomenon, very much a function of the context in which the network is called to operate.
3. Optimality in network structure and an agent’s position in it are determined, at least partly, by the purpose of the network and the strategic orientation of the agent.

The following sections of the chapter survey and synthesize important concepts of interest to the analysis of innovation networks. We draw on recent conceptual developments in the business and sociological literature regarding social capital/network resources, information/learning, network governance, network emergence, and network structure optimality and discuss their influence on firm strategy in industrial sectors characterized by rapidly changing technologies.

2. SOCIAL CAPITAL – NETWORK RESOURCES

Sociologists distinguish between social capital and human capital (Burt, 1992, 1997; Bourdieu and Wacquant, 1992; Coleman, 1990). Social capital is a quality created between people, whereas human capital is a quality of individuals. Social capital is, in a sense, the contextual complement to human capital: returns to human capital attributes such as intelligence, education, and seniority depend in part on the person’s location in the social structure of a market or hierarchy. While human capital refers to individual ability, social capital refers to opportunity. Individuals with more social capital get higher returns to their human capital because they are positioned to identify and develop more rewarding opportunities. Consequently, the investments to build social capital are different from the investments that build human capital (Coleman, 1988, 1990).

Scholars have conceptualized social capital as a set of social resources embedded in relationships as well as the norms and values associated with social relationships (Burt, 1992; Coleman, 1990; Walker et al., 1997). The broad view of social capital encompasses many aspects of a social context, such as social ties, trust relations, and value systems that facilitate actions of individuals located within that context (Tsai and Ghoshal, 1998). Drawing on Granovetter (1992) and others, Nahapiet and Ghoshal (1997) have distinguished between the structural, the relational, and the cognitive dimensions of social capital. The structural dimension includes social interaction: the location of an actor’s contacts in a social structure of interactions provides certain advantages to the actor. The relational dimension refers to assets that are rooted in these relationships, such as trust and trustworthiness. The cognitive dimension refers to attributes like a shared paradigm that facilitates a common understanding of collective goals and proper ways of acting in a social system. This dimension captures the
essence of what Coleman (1990) described as “the public good aspect of social capital.”

The three dimensions of social capital are interlinked (Tsai and Ghoshal, 1998). Social interaction ties (structural dimension) may stimulate trust and perceived trustworthiness (relational dimension). For example, an agent in a central network position can be perceived as more trustworthy by other agents. Common values and a shared vision of collective goals and aspirations (cognitive dimension) may also encourage the development of trust relationships. Finally, social interaction plays a critical role both in shaping a common set of goals and values and in the sharing of those goals and values among network members.

The social capital of individuals is akin to the network resources of firms (Walker et al., 1997). According to Bourdieu and Wacquant (1992, p. 119),

Social capital is the sum of the resources, actual or virtual, that accrue to an individual or a group by virtue of possessing a durable network of more or less institutionalized relationships of mutual acquaintance and recognition.

And, according to Coleman (1988),

social capital inheres in the structure of relations between actors and among actors. It is not lodged either in the actors themselves or in physical implements of production. Because purposive organizations can be actors (“corporate actors”) just as persons can, relations among corporate actors can constitute capital for them as well.

Distinct from other firm-specific resources, network resources reside in the formal and informal inter-organizational networks in which firms are embedded and can be utilized by the firm for strategic conception and implementation. The available network resources can influence firms’ strategic behavior by altering the opportunity set available to them. The investments necessary to create and maintain network resources are distinct from the investments to create and maintain firm-specific resources.

3. NETWORK INFLUENCE ON MEMBER ORGANIZATIONS

The literature has recognized two channels of network influence on members (Gulati, 1998). The first relates to informational benefits obtained through network ties and positioning. The second relates to control benefits that are generated by being more advantageously positioned in the network
or by being part of a tightly knit network. Although analytically different, these two benefits also overlap significantly since the control benefits largely emanate from the possession and manipulation of information.

**Informational Benefits of Networks (Cognition)**

The information benefits of network embeddedness have been summarized by Burt (1992) as access, timing, and referrals. Access refers to information about current and potential partners regarding their assets, capabilities, and trustworthiness. Timing means having the information at the right time. Referrals apply to information, passed through indirect links, about other organizations with which the firm has not had direct contact and about market or technological developments of interest. The location of a firm in a network is important for the referral component: advantageous location means that indirect referrals of partners and of their activities will flow faster and more reliably (through triangulation) than if the company was located in the network’s fringes. The specific network location, in other words, confers different degrees of information.

Powell et al. (1996) argue that when knowledge that brings competitive advantage is widely distributed, inter-organizational collaborative networks become the locus of innovation. While internal capabilities, both for the creation of new knowledge and for the absorption of knowledge produced externally, are of vital importance, networks serve in such cases as innovation loci because they provide timely access to resources and to knowledge that are otherwise unattainable, and test internal learning capabilities. In addition to innovation-related knowledge, firms learn to operate synergistically and develop routines to that effect. They learn how to transfer technology across partnerships and how to locate themselves in advantageous network positions that enable them to keep abreast of pertinent scientific and technological developments. As stated in Powell et al. (1996) “collaboration is both an admission ticket to an information network and a vehicle for rapid communication of news about opportunities and obstacles”.

Organizations learn which collaborations to pursue, how to function in the context of multiple collaborative ventures, and how to adapt their cooperative strategies in the midst of dynamically evolving network structures, a competency that becomes particularly important in high technology fields where frequent scientific and technological advances change the relative benefits of different forms of collaboration. Collaboration becomes, then, emergent (Kogut, 2000). Learning from prior experience makes collaboration between parties easier (cheaper) to uphold because of the continuous refinement of collaboration routines and the attainment of partnering reputations.
There are two channels for informational benefits to network members: direct ties (relational embeddedness); and through the positioning of partners in the network (structural embeddedness). Both channels are described below.

**Relational embeddedness**

The concept of relational embeddedness (Rowley et al., 2000) can be traced back to the original definition of tie strength for individual actor networks proposed by Granovetter (1973, p. 1361): “[A] combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie.” Extended to inter-organizational alliance networks, tie strength translates into broader and deeper commitment in terms of both actual investment and investment in the relationship. Traditional equity joint ventures may be considered as an example of strong inter-organizational ties.

Strong ties have been associated in the literature with the exchange of high-quality, complex information, as well as tacit knowledge. These ties imply a finer mutual understanding of partners’ operations and deeper interpenetration of each others’ organizational boundaries (Uzzi, 1996). In contrast, weak ties were proposed by Granovetter as the appropriate means for accessing new information. He argued that weak ties are more likely to serve as local bridges between relatively disconnected areas of the network and connect the agent with others that possess unique information (thus, implying more of a search activity than an exploitation activity).

Tie strength also relates to network structure and is discussed further in the relevant section below. Both tie strength and network structure are relevant also to network governance, the subject of which is addressed later on, as well.

**Structural embeddedness**

Burt (1992) distinguished conceptually between tie strength and tie density. He argued that when the objective is to access new knowledge, tie density (strong network interconnection) creates redundancy. He suggested that efficiency in accessing knowledge improves by shedding redundant ties in favor of establishing selective ties that bridge “structural holes” (empty spaces in the network).

It is now well understood that the information passing through networks is influenced by each participant’s position in the network structure (Powell et al., 1996). Differential location in a network results in firms having divergent capabilities for benefiting from information flows. Firms with more experience in collaborating can better locate themselves in
information-rich positions in the network with access to a more diverse set of activities. More central positioning, locally or globally, generates visibility and reputation, and thus facilitates timely access to information and resources. Firms more centrally located should have more timely access to promising new opportunities and ventures. Their experience should also result in better capabilities to benefit from further relationships.

Put differently, the status of an organization in the network affects its reputation and visibility in the system. The signaling properties of status are particularly important in uncertain environments: if partner status enhances their own attractiveness, organizations will have a tendency to seek high-status partners (Podolny, 1993; Podolny and Page, 1998; Podolny et al., 1996).

Research has shown that firms with larger sets of network ties and more central network locations are more likely to be part of new ties, and this seems to hold for various types of networks including partnerships, patent citation networks, and top management teams. Each network highlights a different underlying social process that enables central firms to enter alliances more frequently (Gulati, 1998; Wagner et al., 2004).

**Control Benefits of Networks (Governance)**

Coleman (1988) proposed that a dense structure with strong ties enables a build up of reputation and social capital in the form of trust and shared social norms across network members. For the same reasons, Meyer and Rowan (1977) and Oliver (2001) argued that firms embedded in highly interconnected networks develop shared behavioral expectations. Consequently, like strong ties, dense networks create a mechanism of control of social relations in inter-organizational networks. According to Rowley et al. (2000), strong ties create trust at the dyadic level by producing goodwill between partners based on interdependence and a history of reciprocity and mutual forbearance. Dense structures also serve as mechanisms of norm creation at the network level as firms are confronted with established customs, higher collective ability to punish disobedience, and expectations that the network will produce effective incentives for cooperation, and facilitate collective monitoring and sanctioning.

The above also agrees with posited concepts of organizational cognition and organizational culture (Nooeteboom and Gilsing, 2004). Organizational culture is an institutional arrangement that enables and constrains actions and sense-making, and includes both relations of power and processes of exclusion (Contu and Wilmott, 2003). Kogut and Zander (1996) and Nooteboom (1992) have argued that organizations set cognitive frameworks for guiding attention, perception and interpretation, and
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for setting behavioral rules, constraining opportunism, building trust, and limiting and resolving conflicts of interest. Norms and values of behavior tend to be internalized by people as part of their tacit knowledge, and are assimilated, to a greater or lesser extent, in socialization and habituation. It is important to notice that the stronger the ties and the denser the set of relationships, the more tightly knit is the network and the more it resembles an organization. The more, then, it tends to create its own culture that both enables and constrains interpretations and actions, and that includes relations of power and processes of exclusion for deterrence of deviant behavior.

Governance and network control are important as they affect the cost of operating the network directly. Dense networks with strong ties and diffused norms and expectations project high degrees of built-up social capital. The cost of participation for incumbents is fairly low given the following characteristics: wide spread of information and significant trust among members; the low chance of opportunistic behavior as a result of lock-in in a relationship with high relation-specific investments; high switching costs; and the ability to control the damage from spillovers.

The dark side of dense (tight) networks is that they may lock in an organization with a group that may prove not to have been the best choice, in organizational or technological terms. More on this below.

4. NETWORK STRUCTURE

In an eloquent paper, Kogut (2000) argued that network structure is emergent in the initial conditions of a specific industry, including the inherent characteristics of the relevant technologies, and the norms and institutional factors that help generate rules that guide the competitive/cooperative behavior of firms in that industry. The argument runs on the elaboration of the characteristics of variety and specialization that are antithetical within the firm but complementary within the network. Using the parallelism of the market and the network, Kogut argues that they basically serve a similar purpose: achieving variety through specialization in the division of labor. The division of labor is the result of a dynamic learning process of individual agents (firms) who specialize (focus) in order to create competence. Firms can be considered social communities that enable specialization in the creation and replication of partly tacit, partly explicit organizing principles of work. The boundary between the firm and the network (market) is determined by the internal cost of production and management relative to the costs of market search and procurement (Coase, 1937). At some point, the internal management of variety in the
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A network is, then, a collection of firms, each ensconced in an identity that supports specialization and a dynamic of learning and exploration. But the network, unlike the firm, does not consist of an authority relationship that can enforce an organizational structure on its members. (Kogut, 2000, p. 409)

Network structure emerges in a self-organizing process from the initial conditions of a specific industry, the characteristics of the relevant technologies, and the norms and institutional factors that help generate rules that guide firm behavior. Behavioral rules and network structure are embraced in an interactive relationship: as rules generate the structure of the network, network structure influences subsequent behavior. The emergent structure dissuades rule-breaking behavior. “The dynamic between internal capabilities, ensonced in specific identities and organizational structures, and the external knowledge in the market (network) drives a co-evolution between the emergent properties in the firm and the network” (Kogut, 2000, p. 412)

Herein lies a fundamental trade-off between organizational stability and variety in network structure. The emergent network properties, as discussed above, are the result of self-organization processes and the accumulation of social capital among partners. The accumulation of social capital is dependent on the maintenance and strengthening of the prevailing relationships. The requisite investment by individual organizations to build social capital naturally tends to create forces for the preservation and strengthening of the existing structures. Hence, a natural tendency emerges to freeze the structure of interactions into stable patterns. The more stable the patterns of interaction become, however, the more the characteristics of firm organization the network acquires; that is, the more it strives for specialization and the less capable it grows in achieving its fundamental objective: variety. Increasing coordination deprives individual partners of the ability to pursue potential avenues of exploration.

5. NETWORK STRUCTURE OPTIMALITY

Latching onto this fundamental trade-off, Walker et al. (1997) emphasized that it is exactly the tendency for preservation and reinforcement of network structures that generates opportunities for entrepreneurial agents to bridge across structures. In so doing, these agents profit individually, as well as alter the form of the network. The argument for network structure optimality is about balancing two opposing forces: the incentive to lower
the operating cost in a network by facilitating information exchange and decreasing relational risk, versus the incentive of profit opportunities by breaking new ground to bridge stable but isolated regions of relationships in the network.\(^4\)

This “entrepreneurial” activity is, of course, the selective establishment of information-rich ties across “structural holes” in the network, a concept that Burt (1992) has strongly advocated. Such ties are non-redundant in the sense that they connect previously unconnected nodes and, as a result, confer powerful brokerage positions. Firms positioned in structural holes are more powerful because they arbitrate the information flows between groups of firms with loose (or no) ties to each other. The rent in this situation accrues to the firm bridging the structural hole. Pushing the argument a bit further, it can be proposed that while there can be entrepreneurial agents from within the network that bridge the holes, it is more likely that there is an inverse relationship between network centrality and such entrepreneurship taking hold. The smaller the stake of an organization in a given network, the higher are its incentives to play the entrepreneurial role and bridge across. The highest possibilities for the entrepreneurial role thus rest with organizations at the network fringes or outside of the network altogether.

Such “entrepreneurial” activity contrasts with the style of networking involved in the closure argument for dense network structures based on solid amounts of social capital that Coleman (1988) had advocated earlier. In Coleman’s world, redundant ties among firms resolve collective action problems and improve coordination. Here, the rent accrues to the group and is allocated among its members on the basis of relative market power and adjudication rules.

Seemingly contradictory, the two styles of networking may actually be complementary, as Burt (1998) has already suggested, providing different advantages to, and being used for different purposes by, firms and other actors. One could perceive the Burt style of networking as creating a counterbalance to the natural tendency for freezing patterns of inter-organizational ties in the Coleman style of networking. In other words, Burt’s style of networking could play a safeguarding role against the progressive demise of variety in increasingly stable networks.

The question, then, becomes one of balance (optimality).\(^5\) That is, a balance that allows for the advantages of stability, when it proves advantageous, and also allows for the recombination of information and (network) renewal, when that path has merits. Economists will quickly recognize the analogy with traditional market analysis: (network) entry and barriers to such entry become key factors for network structure and its rejuvenation, exactly as they do in markets where entrants dilute the
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strongholds of incumbents. Similarly to achieving optimality in markets, achieving balance in networks will be complex and will vary across activity areas (e.g. sectors).

Optimality in this sense is difficult to achieve, not least because of the “emergent” properties of network structure. The solution will, at least in part, depend on whether the predominant mode of operation in a sector concentrates on the better exploitation of existing technologies, skills, and information, or the exploration of emerging innovations and other changes (March, 1991). Generally speaking, exploitation signifies improvement of established practices whereas exploration signifies the development of new practices. Intimately related to the achievement of economic efficiency (lower cost for given output or more output for given cost), exploitation requires organizational routines that, in the case of networks, can be defined as, “repetitive, recognizable patterns of interdependent actions, involving multiple actors” (Feldman and Pentland, 2003, p. 96). That is, exploitation involves the use of existing information to improve efficiency and returns from present strategies, competencies, and procedures. In contrast, routines are subject to change in exploration. Exploration involves searching for and experimenting with emerging innovations with good future prospects of profitability.

It is reasonable to anticipate that both processes are often needed, pursued simultaneously, and compete for limited resources within individual organizations (March, 1991). The ensuing strategic trade-off is a classic one in economics. It pits short-term investment in the refinement of existing technologies for immediate, but relatively low-margin returns, against longer-term investment in radically new ideas and technologies for future, but potentially much higher-margin, returns. The optimal allocation of resources between the two will depend on the internal conditions of the firm (resources, capabilities, strategic inclination) and on environmental factors relating to both the demand side (conditions for market development) and the supply side (technological opportunity, appropriability, competitive conditions). Environmental uncertainty will tend to push for more exploration by increasing the need for innovation. According to this line of argument, then, the type and optimal amount of social capital for an organization to maintain will change in accordance with the distinct strategic mixtures of exploitation and exploration pursued by that organization in different environments (Nooteboom and Gilsing, 2004; Rowley et al., 2000).

On the basis of the different information requirements between exploitation and exploration, Rowley et al. (2000) have argued for high-density and strong ties for exploitation and for low-density and weak ties for exploration. Strong ties are said to facilitate rich exchanges of fine-grained
information to assist firms in obtaining a deep understanding of a specific innovation in order to refine and improve it. Weak ties are said to be especially important for flexibility and low-density network structures preferable for broad searches in uncertain environments requiring relatively high investments in exploration.

Hagedoorn and Duysters (2002) reach the opposite conclusion: it is dense networks and redundant ties that may be conducive to experimentation and learning through contacts and not strict rules of network efficiency maximization. They reason on the basis of bounded rationality (Cyert and March, 1964; Nelson and Winter, 1982; Simon, 1957). In the context of dynamic environments with frequently changing conditions and continuous learning by companies, they argue, the efficiency of information transfer through bridges across existing local networks – while avoiding duplication of contacts – becomes less relevant as a realistic strategy. In dynamic environments characterized by rapid technological advance, openness of contacts, network density and tie redundancy are said to be preferable to efficiency-based behavior.

Nootenboom and Gilsing (2004) argue somewhere in between. Loose and non-redundant ties may be best for the identification of knowledge, whereas strong ties are needed for the transfer of complex and highly tacit knowledge. On the basis of bounded rationality and uncertainty concerning future dominant designs of technology, organization, and consequential configuration of future networks of exploitation, they expect dense networks and redundant ties in the case of exploration. Ties will be strong in some respects (scope, frequency, trust/mutual openness), show less strength in terms of relation-specific investments and duration, and little strength in terms of control. In contrast, less dense, more stable network structures and non-redundant ties are anticipated for exploitation. Increased specialization, reduced scope and reduced need for trust (more control) reduce frequency of interaction.

Moreover, Nootenboom and Gilsing (2004) discuss the important issue of the transition from exploration to exploitation with the development of a dominant design. They expect hybrid forms of networks to arise in transitions between, and through, combinations of exploration and exploitation. One theoretically possible form of hybrid network could be visualized as an intermediate network that links networks for exploitation and networks for exploration. Another form could be represented by a core network of exploitation connected to peripheral networks of exploration. Finally, exploration networks may be transformed into exploitation networks with larger scale organizations, elimination of redundancy, emergence of centrality, larger specific investments, less informality, fewer personalized relations, more distrust and more formal control.
6. SUMMARY AND CONCLUSION

Several important concepts for the strategic and policy analysis of inter-organizational innovation networks were discussed in this chapter. One relates to the network resources of firms. Like the social capital of individuals, network resources have a structural dimension determined by the location of an actor’s contacts in a network, a relational dimension indicating their relationship assets such as trust/trustworthiness, and a cognitive dimension reflecting a shared paradigm that facilitates interaction in the network. Distinct from other firm-specific resources, network resources reside in the formal and informal inter-organizational networks in which firms are embedded and can be utilized by the firm to conceive of and implement its strategies. Available network resources can influence firms’ strategic behavior by altering the opportunity set with which they are presented. The investments necessary to create and maintain network resources are distinct from the investments to create and maintain firm-specific resources. Organizations are typically embedded in more than one inter-locking network at any given point of time.

Networks confer informational benefits to their members that can be summarized as access, timing, and referrals. These informational benefits flow through two channels: the direct ties of the organization (relational embeddedness) and its positioning in the network (structural embeddedness). Strong ties have been traditionally associated in the network literature with the exchange of high-quality, complex information and tacit knowledge, whereas weak ties have been considered appropriate means for accessing new information. Weak ties are more likely to serve as local bridges between relatively disconnected areas of the network, and to connect the agent with others that possess unique information. Efficiency in accessing knowledge may improve by shedding redundant ties in favor of establishing selective ties that bridge “structural holes.” Importantly, each participant’s position in the network structure influences its capabilities for benefiting from the network: more central positioning (locally or globally) generates visibility and reputation and facilitates timely access to resources and information. This, in turn, raises the status of the organization in the network and makes it especially desirable as a partner. Such “preferential attachment” processes lead to skewed distributions of linkages in networks of all kinds, including innovation networks.

When the knowledge underlying competitive advantage is widely distributed, inter-organizational cooperative networks become the locus of innovation. Organizations learn which collaborations to pursue, how to function in the context of multiple collaborative ventures, and how to adapt their cooperative strategies in the midst of dynamically evolving
network structures. Such competencies become particularly important in high technology fields where frequent scientific and technological advances change the relative benefits of different forms of collaboration.

Networks also confer control benefits for their members. Control benefits are generated when firms are more advantageously positioned in the network or are part of a tightly knit network. A dense network structure with strong ties enables firms to build reputation and social capital in the form of trust and shared social norms across network members. Strong ties create trust at the dyadic level, while dense structures serve as mechanisms of norm creation at the network level. Dense networks and strong ties decrease the cost of network operation. Moreover, the stronger the ties and the denser the set of relationships, the more tightly knit is the network and the more it resembles an organization. The more it then tends to create its own culture that both enables and constrains interpretations and actions, and that includes relations of power and processes of exclusion for deterrence of deviant behavior. The dark side of dense networks is in the form of fewer degrees of freedom for members because of lock-in.

An important concept in the literature is that network structure is emergent in the initial conditions of a specific industry, including the inherent characteristics of the relevant technologies, and the norms and institutional factors that help generate rules that guide the competitive/cooperative behavior of firms in that industry. In addition, it is now understood that the market and the network basically serve a similar purpose: achieving variety through specialization in the division of labor. In contrast, firms (hierarchies) enable specialization. The boundary between the hierarchy and the network is determined by transaction costs.

This points out a fundamental trade-off in network structure between organizational stability and variety. The accumulation of social capital is dependent on the maintenance and strengthening of the prevailing relationships; hence a tendency to freeze the structure of interactions into stable patterns. The more stable the patterns of interaction become, however, the more the characteristics of firm organization the network acquires; that is, the more it strives for specialization and the less capable it grows of achieving its fundamental objective of variety. Increasing coordination deprives individual partners of the ability to pursue potential avenues of exploration.

It is important to emphasize that network structure optimality will, at least in part, depend on whether the predominant mode of operation in an industry concentrates on the better exploitation of existing technologies, skills, and information, or the exploration of emerging innovations and other changes. Both processes are often needed, pursued simultaneously, and compete for limited resources within individual organizations. The
optimal allocation of resources among the two will depend on the internal conditions of the firm (resources, capabilities, strategic inclination) and on environmental factors relating to industry characteristics, including both the demand side (conditions for market development) and the supply side (technological opportunity, appropriability, competitive conditions). The type and optimal amount of social capital for an organization to maintain will then change in accordance with the organization’s strategic mixture of exploitation and exploration in different environments.

On the basis of the different information requirements between exploitation and exploration, analysts have argued for high-density and strong ties for exploitation and for low-density and weak ties for exploration. Others have reached the opposite conclusion by using bounded rationality arguments: in dynamic environments with frequently changing conditions and continuous learning by companies, the efficiency of transferring information through bridges in existing networks while avoiding duplication of contacts is argued to become less relevant than openness of contacts, network density and tie redundancy. Still others argue somewhere in between: dense networks, redundant ties, and variable tie strengths are expected in the case of exploration; less dense, more stable network structures and non-redundant ties are anticipated for exploitation. Moreover, hybrid network forms are anticipated in transitions from exploration to exploitation in the development of a dominant design.

We have thus come full circle: in order to determine the incentives (net benefits) of a firm to participate in a network, one needs to address network structure optimality and the firm’s positioning in the network which, in turn, requires addressing the relationship between industry (activity) characteristics and firm strategy. This should not be surprising, given that networking is part of the more general strategic orientation of the firm, which itself is influenced by the characteristics of the economic activity in which the firm is engaged in the first place. In other words, network analysis must be complemented with more traditional investigations of market structure, technological advance, competitive behavior, and company performance. A particularly promising, in our view, avenue of investigation that can combine all these aspects would be the analysis of the co-evolution of industry and network structure, especially in sectors of rapid technological advance.

NOTES

1. This process is often called preferential attachment. Let \( P(k) \) be the probability that a randomly selected node has \( k \) links (degrees). It is commonly found in the literature that,
for a sufficiently large $k$, the degree distribution of many networks follows the power law $P(k) \sim k^{-\gamma}$, with $2.1 < \gamma < 4$, irrespective of the network origin (Barabási and Albert, 1999). This means that most network members have few links whereas a minority of members has disproportionately large numbers of links. Networks following a power law are referred to as scale-free networks since they lack a “typical” characteristic degree (Willinger et al., 2002).

2. Contrast this to Burt’s (1992) argument for less dense structures in the previous section.

3. Rowley et al. (2000) then argue that dense networks and strong ties are, to some degree, substitutes for one another. A firm will gain much less from strong ties in a dense network than when its partners are sparsely connected. The structure itself in a dense network has produced behavioral norms to guide actions.

4. The analogy of the forces for preserving or altering the network structure to the incentives for maintaining the existing market structure or altering it through innovation should be obvious to economists.

5. This is not assumed as a static concept. Optimality evolves in time together with the factors responsible for an emergent network structure.

6. Evolutionary economics has offered extensive discussions on the use of organizational routines and their adaptation to new conditions, or abandonment, through time (Hodgson, 1993; Nelson, 1995; Nelson and Winter, 1982).

REFERENCES


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