Chapter 11

Knowledge networks and the geographic locus of innovation

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Submitted for
Henry Chesbrough, Wim Vanhaverbeke and Joel West, eds.,
Open Innovation: Researching a New Paradigm, Oxford University Press (2006).

October 30, 2005

Introduction

A crucial goal of Open Innovation is to capture external knowledge that flows between organizations, allowing firms to be more successful at innovation than firms that close off such flows. As has been discussed in Part I, one goal of external innovation is to capture the value of internal knowledge transferred to other firms. In other cases, firms find it more efficient and effective to incorporate external knowledge rather than develop it internally. In the overall scope of innovation, most new ideas emerge from outside companies, and those that emerge inside can leave if not quickly captured (Chesbrough, 2003a; Moore and Davis, 2004). However, prior research on Open Innovation has mostly focused on the firm level of analysis and has not emphasized the role of the firm's external institutional and geographic context in shaping the flows of knowledge that the firm can act on in pursuing an Open Innovation strategy.

In this chapter, we consider the context of firm innovation by building upon prior research on interorganizational networks and innovation and their implications for Open Innovation. Networks are an inherent part of an organization's institutional environment and, whether formal or informal, are key conduits through which knowledge travels from the environment to the firm. Furthermore, such networks often have a geographical locus, as with the dense networks that form within a regional economy. Despite the availability of global travel and electronic communications, regional networks such as the ties that are the fabric of Silicon Valley continue to play an important role in interorganizational knowledge flows. Government policy often seeks to encourage such innovative knowledge flows through efforts to synthesize or strengthen national innovation systems.

To explore the implications of the network literature for Open Innovation, we begin by reviewing prior research on network organizations and interorganizational networks. We then

consider studies on regional and national innovation systems and their impact on knowledge flows between firms. From this, we offer a framework of how firms build networks to support Open Innovation based on key network dimensions that are likely to influence the flow of knowledge to the firm, and conclude with suggestions for future research linking the two bodies of research.

Knowledge Flows, Networks and Innovation

Knowledge flows between firms are crucial to many innovations. Such knowledge flows through networks of formal and informal ties, enabling firms to build upon the broad pool of knowledge outside the boundary of the firm.

Interorganizational Knowledge Flows

Knowledge and information are distinct constructs. Information has the potential to be used in a way that creates new knowledge, or adds to or transforms existing knowledge (Machlup, 1983; Nonaka, 1994). Unlike information, knowledge requires a knower: "information is a flow of messages, while knowledge is created and organized by the very flow of information, anchored on the commitment and beliefs of its holder" (Nonaka, 1994: 15). Thus knowledge flows through and resides in individuals.

Knowledge is often subdivided between tacit knowledge — that which is not articulated or codified — and explicit knowledge (Polanyi, 1967; Nonaka, 1994). Because tacit knowledge is generally harder for competitors to imitate, it generally has greater competitive value (Nelson and Winter, 1982). One problem in operationalizing the distinction between the two types of knowledge has been an absence of bright line tests between the two categories (Cowan, David and Foray, 2000; Johnson, Lorenz and Lundvall, 2002)[i]. However, firms use both tacit and explicit knowledge to increate innovations (Cowan et al., 2000).

Essential knowledge flows along the value chain, between customer and supplier, where highly tacit knowledge may be necessary to use an innovation or for a supplier to refine its offering to meet customer needs. Von Hippel (1988, 2005) also notes that customers themselves often refine innovations or identify new ideas. In other cases, firms work closely with suppliers of complementary products to complete the whole product offering (Teece, 1986; Moore, 1991). In many cases, firms must organize and lead an entire value network to support their specific innovations (Christensen and Rosenbloom, 1995; Iansiti and Levien, 2004a; Maula et al, Chapter 12). Universities transfer scientific knowledge, whether through their faculty research or through the education carried in their students (Audrescht, Lehmann, and Warning, 2004).

Conversely, unintended knowledge spillovers occur between firms, as when labor mobility allows a firm's knowledge to "walk out the door" and end up at a customer, supplier or competitor. The conduit for desirable and undesirable knowledge flows is through people, both through mobility and through interpersonal interaction between individuals (Kogut and Zander, 1993; Spender, 1996). This is particularly true for the tacit knowledge held by individuals which is an essential antecedent to creative breakthroughs (Polanyi, 1967).

To "seal" valuable knowledge within their boundaries, firms have used a variety of approaches, including developing new technologies in-house from scratch, surrounding their R&D activities with secrecy, closing their boundaries through non-compete and non-disclosure agreements, and acquiring external knowledge through costly vertical integration strategies (Chesbrough, 2003a). But if, as Chesbrough (2003a) argues, most new knowledge emerges outside the firm, then approaches to closing the boundaries of the firm run the risk of overlooking opportunities from the far larger pool of knowledge outside the firm — while failing to prevent the leakage of knowledge that will eventually escape the firm if not acted upon. Open

Innovation, in fact, seeks to address both issues, by creating processes for incorporating such external knowledge as well as capturing a return from potential outflows.[ii]

Networks and Innovation

In contrast to the market and hierarchical forms of Williamson (1975), Powell (1990) identified a third alternative, the network organization. This form considers the identity and enduring reputation of the organizational actor as important, enforcing a norm of reciprocity and interdependence between network members (Powell 1990). Networks are highly flexible (Piore and Sabel 1984) and are embedded in ongoing relationships between social actors, where sanctions are reputational rather than normative. Network forms in the new economy are made of big and small players alike, across multiple industries, and encompass multiple types of ties (Powell 2001; Stark 2001).

Network ties may reflect formal collaboration, such as joint ventures, alliances or R&D partnerships. They may correspond to customer-supplier relationships (such as licensing, contracting, or providing key components) or more lateral alliances to co-market or develop complementary products. Or they may reflect informal ties between individuals, built through past collaborations (which might be sanctioned or unsanctioned).

Like the network form, Open Innovation is a value-creation strategy that is an alternative to vertical integration. In Open Innovation, some firms need to identify external knowledge and incorporate it into the firm; others seek external markets for their existing innovations (West and Gallagher, Chapter 5). The pathways of network ties create opportunities for both types of Open Innovation. Accessing a network allows a firm to fill in a specific knowledge need rapidly, without having to spend enormous amounts of time and money to develop that knowledge internally or acquire it through vertical integration. Similarly, networks can facilitate (or result

from) efforts to commercialize internal technologies, such as through creation of a spinoff, corporate venture investment in a startup, or establishment of a joint venture.

Prior research has shown the role of interorganizational ties in enabling firm innovation. Teece (1989) showed how cooperation between companies increases knowledge gain and reduces the inherent waste of duplicated effort. Networks have been found to have beneficial returns on innovation such as increased patenting rates, improvements on existing products and new product creation, faster time to market, and access of new markets (Almeida and Kogut, 1999; Baum et al, 2000; Powell et al 1996; Gemunden, Ritter, and Heydebreck, 1996). By providing access to complementary skills, scale benefits, and a broader knowledge base, network ties positively influence firm innovation (Shan, Walker, and Kogut 1994; Powell, Koput, Smith-Doerr, and Owen-Smith 1999; Ahuja 2000; Baum, Calabrese, and Silverman 2000). Studies further showed that firms involved in multiple types of ties are more innovative than organizations that engage in a single type of tie, since different types of ties can transfer different types of knowledge (Powell et al. 1999; Baum et al. 2000).

Networks are especially well suited to knowledge-intensive industries where joint problem solving is paramount: networks foster problem solving and learning mechanisms (Powell, Koput, and Smith-Doerr 1996). Hence, the Open Innovation phenomenon has been most often identified in technology-intensive industries (Chesbrough 2003a), although using networks to tap into external knowledge is potentially relevant for companies in all industries. Innovation-related knowledge is not just limited to technical knowledge, but may also include the knowledge necessary to commercialize an innovation, such as the knowledge of customers, market segments and product applications. Such knowledge may come from customers or other partners in the value chain (von Hippel, 1988, 2005; Lynn et al, 1996; Chesbrough and Rosenbloom, 2002).

Formal and Informal Ties

Organizations and individuals are embedded in networks, and thus both interorganizational and interpersonal knowledge flows are guided by the formal institutionalized and the less visible informal interrelationships of those involved in innovative activities.

Formal ties are contractually agreed upon, planned channels for knowledge exchange between organizations, such as a strategic alliance. These ties are more easily incorporated into an Open Innovation strategy: a firm can identify gaps of internal knowledge and then seek potential partners for collaboration to fill that knowledge without having to build it internally.

While planned and thus part of a firm's strategy, formal ties can also have unexpected knowledge spillover benefits. Formal ties such as licensing agreements and alliances also represent channels for informal knowledge flows, and are "more open than their portrayal as pipelines suggests" (Owen-Smith and Powell 2004). For example, a joint technology development agreement will not only foster the planned technological knowledge exchange, but also can enable labor movement between the two companies, create access to unforeseen knowledge through informal ties between those individuals developing the technology, and thus create a possibility of tapping into the networks of the respective participants. Formal ties between organizations are embedded in social networks (Gulati 1998), consistent with economic sociology's view that economic action is embedded in social structures (Granovetter 1985; Uzzi 1994). In the Open Innovation context, the challenge for firms is to develop the capabilities to recognize those unanticipated spillovers and capture their potential benefits.

Informal ties provide an important pathway for flows of valuable knowledge — particularly for exploiting unforeseen knowledge opportunities. Informal and unplanned ties can lead to knowledge spillovers (Agrawal and Henderson 2002; Murray 2002), when individuals move

between companies or are members of a community that spans multiple organizations. Informal ties may emerge as the consequence of formal ties, or they conversely can open paths to the formation of formal ties (Gulati and Westphal, 1999).

Knowledge can flow through people moving between organizations. Labor market mobility is an important source of network ties between organizations in regional economies such as Silicon Valley (Castilla et al, 2000; Cohen and Fields 2000). These informal ties are a source of human and social capital[iii] for organizations (Murray 2002; Porter 2004). That is, an individual's stock of knowledge, experience, skills, and connections are brought to an organization at the time of hiring. Knowledge has been shown to flow through career movements (Almeida and Kogut 1999). People moving between organizations in a region is one way through which knowledge is transferred and applied to new contexts, leading to innovation. Almeida and colleagues (2003) concluded that informal knowledge flow mechanisms benefited small firms more than large firms.

In past research, organizations have been characterized as social communities involved in knowledge creation and transfer (Kogut and Zander 1996). Studies report that entrepreneurs typically gain knowledge of an industry in existing companies before founding a firm of their own (Sorenson and Audia 2000). Not only do past career experiences affect an individual's stock of knowledge, but these experiences also affect the social networks that one can draw upon to support subsequent economic activity (Uzzi, 1996). Embeddedness has been shown to favor organizational performance up to a threshold point, where it becomes detrimental by cutting off external sources of information (Uzzi, 1996; 1997).

Social networks affect the creation of further intellectual capital by promoting knowledge sharing and innovation (Coleman 1988; Nahapiet and Ghoshal 1998; Sorenson and Audia 2000).

Some research has emphasized that groups of individuals share knowledge through a community-of-practice, an informal network of knowledgeable people who share a common work identity and create knowledge flows across organizational boundaries (Brown and Duguid 2000). Thus, an Open Innovation strategy would need to recognize the external knowledge opportunities possible from their employees' embeddedness through informal network ties.

The Geography of Open Innovation

Open Innovation benefits may be more readily achieved in regional clusters, since the effect of networks on innovation is magnified by geographic proximity; such clusters are defined as "geographic concentrations of interconnected companies and institutions in a particular field" (Porter 1998). Marshall (1920) first noted regions that are rich in ideas (and thus knowledge) will attract economic activity. Economists have pointed out the benefits of localization on economic growth (Romer 1987; Stuart and Sorenson 2003), such as reduced production and transport costs leading to increased access to markets and economies of scale, specialized labor markets, and the lower costs of accessing information locally (Weber 1928; Rotemberg and Saloner 1990; Krugman 1991; Maskell 2001).

Less developed are the linkages between networks and geography. While many have described the geographical nature of knowledge flows, very few studies have quantitatively measured the effect of geography on such flows and on innovation. A few studies show that knowledge flows more readily to closer entities (Jaffe, Trajtenberg, and Henderson 1993), whether through organizations or through individual labor mobility (Almeida and Kogut 1999). Owen-Smith and Powell (2004) stress that interorganizational networks act as a signal of membership in a local community of knowledge. Recent research confirms that membership in a regional community increases innovation benefits (Bunker Whittington, Owen-Smith and

Powell, 2004). This regional network effect applies both to high-technology and other industries such as apparel (Uzzi, 1996, 1997), shoes (Sorenson, and Audia, 2000), knitwear (Lazerson, 1995) and wine (Benjamin and Podolny, 1999).

Networks have been a key building block of the formation of regional economies in high-technology (Saxenian 1996) and in biotechnology (Owen-Smith and Powell 2004, forthcoming); startup firms in those regions have long recognized that co-location enables them to tap into necessary knowledge. High-technology regions can be viewed as multidirectional knowledge flows (Brown and Duguid 2000), or as Porter and colleagues (2006) put it, "the intersection of multiple networks is the wellspring of technology clusters." Networks of co-located organizations are necessary to construct a regional social structure of innovation and the knowledge flows that lead to innovative activity (Owen-Smith and Powell forthcoming).

Key Institutions

Regional innovation is enabled by the knowledge exchanges among a diverse set of institutions and organizations. An optimal Open Innovation strategy would exploit multiple types of ties to multiple types of institutions, as each type of tie and institution favors the flow of different pieces of knowledge.

Universities. First among institutions known for creating basic knowledge is the university. While fully integrated firms once were renowned for their basic research abilities, the Open Innovation framework calls for tapping into other institutions with that basic research capability. Universities have been shown to be a central creator of such basic knowledge in regional economies (Teece 1989; Rosenberg 2000; Miner, Eesley, Devaughn, and Rura-Polley 2001; Kenney 2000b).

High-quality research universities produce knowledge spillovers through such formal interfaces such as commercialization initiatives (patenting and licensing), industrial parks, and informal flows of students entering the labor market (Saxenian 1996). As research institutions with a culture of knowledge sharing, universities tend to generate more knowledge spillover effects in regions than other organizational forms (Dasgupta and David 1994; Owen-Smith and Powell 2004). However, increasing attempts by universities to profit from their research are potentially reducing those spillovers (Fabrizio, Chapter 8).

Venture capitalists (VCs) are another important source of regional knowledge since they are actively involved in the creation of start-up companies (Gompers and Lerner 1999; Hellmann 2000; Kenney and Florida 2000; Kortum and Lerner 2000; Leslie 2000). With their ties to multiple startup companies, venture capitalists can help identify needed knowledge and potential synergies that are beneficial to both established companies and startups. VCs' knowledge base is geared toward commercialization of innovation and act as connective agents in a regional economy (Owen-Smith and Powell, 2004).

VCs are a "powerful institutional force" that are inherently focused on commercialization of technologies, converting ideas into products, and hence can be a crucial partner in an Open Innovation model (Chesbrough, 2003a). Firms create informal ties through joint participation in advisory boards, trade associations and other indirect collaborations. Formal ties to venture capitalists can be created in a variety of ways, such as creating formal ties through joint investments in startups or spinoffs. Firms can also create captive venture capital divisions to access external knowledge and commercialize firm technologies, as with Intel Capital (Chesbrough 2003a) or Qualcomm Ventures (Simard 2004).

Focal Firms. Another oft-cited force of knowledge creation in a regional economy is the presence of a highly successful start-up that acts as a breeding ground for knowledge creation and further ventures. In Silicon Valley, Fairchild Semiconductor and Hewlett-Packard are often depicted as key generators of future startups (Lecuyer 2000). In Helsinki's telecommunications cluster, Nokia has been identified as the "star organization" attracting other multinationals to the region and ensuring a steady flow of knowledgeable workers and entrepreneurs (Porter and Solvell 2000);[iv] for San Diego's telecommunications cluster, Linkabit played a Fairchild-like role in generating spinoffs while Qualcomm was the star organization (Simard, 2004). Hence, companies in a cluster may gain some innovation benefits by favoring network ties to a local "star" organization over less known companies. Star organizations may fluctuate over time; recently, Google has replaced HP as a "star" organization in Silicon Valley acting as a major attractor for knowledge and talent.

Each industry may have its own institutions that lead to location innovation benefits. In biotechnology, for example, public research institutes may be an important source of knowledge (Owen-Smith and Powell, 2004). According to the context, other key government entities may include the military, which provided both markets and knowledge spillovers for the development of clusters in semiconductors (Leslie, 2000) and wireless communications (Simard, 2004). Other organizational forms such as law firms and consultants can also act as important sources of knowledge or bridges to other organizations (Suchman, 2000; McKenna, 2000) and vary in their organizational form and spatial distribution depending on the type of industry (Kenney and Patton, 2005).

National Innovation Policies

In a broader geographic scope, policymakers have sought to identify and systematize policies that enable the creation and incorporation of innovation within a national economy. Variously referred to as "national systems of innovation" (Lundvall, 1992) or "national innovation systems" (Nelson, 1993; Montobbio, 1999), contemporary research on such national innovation policy has attempted to link between-country differences in innovation outcomes to differences in their respective supporting institutions. The studies focus on the role of nation-state in enabling (or constraining) innovation activities, focusing on institutions that facilitate collaborative innovation such as university and government-sponsored research, as well as many of the same spillover issues as the regional innovation literature. The work often attempts to identify policy proscriptions that will allow a national policy body to improve innovation creation and flows. Thus, understanding the differences between innovation systems (as well as the antecedents of such differences) would help us to anticipate national differences in the degree and nature of Open Innovation. Such understanding would also help us understand the relationship between changes in innovation systems and changes in Open Innovation.

In some cases, the policy linkages are overt, as with direct government subsidies for industrial research, or indirect subsidies through government procurement of military or other goods. Such research benefits both the direct recipients and related firms through spillovers to civilian applications (Nelson, 1993; Steinmueller, 1996; Bresnahan and Malerba, 1999). In this case, the government acts as what Chesbrough (2003a) terms an "innovation benefactor," creating external sources of innovation without attempting to appropriate the full returns of such innovation. However, spillovers from military projects are often accidental, as in the shift from military to commercial technology in San Diego's "Wireless Valley" (Simard, 2004).

Other research has sought to identify the role played by non-governmental institutions to explain national differences in their ability to exploit new technological opportunities, based on the flow of tacit knowledge and organizational learning (McKelvey, 1991; Lundvall 1992; Mowery 1996). Early studies attempted to isolate specific "national" patterns of innovation common across all high-tech industries in a given country. So the studies edited by Nelson (1993) show that industries with high up-front R&D costs tend to be found in large, affluent countries — except for those smaller countries (e.g., Sweden, Israel, Korea) with disproportionately large defense industries. The more successful firms have been exposed to stronger competition, typically but not always in their home market (Porter, 1990; Nelson, 1993).

However, a key limitation is that these studies have assumed that between-country differences in innovation institutions are more important than within-country ones. Other studies have noted the importance of firm-specific factors to explain the relative success of national industries (Dertouzos et al, 1989; Chandler, 1990; Nelson, 1993). Mowery and Nelson (1999) combine the two approaches with the concept of "industrial leadership" to encompass both firm and industry effects

Of course, in a globalized environment, many firms source technology and seek customers across national boundaries. Still, home market customers play an important role in developing the innovative capabilities of firms (Porter, 1990). And labor markets remain one of the few innovative inputs that are imperfectly traded across national boundaries, due to lingering labor market protectionism (Rodrik 2000).

Thus we would expect to find several key national factors to explain the differences in the application of Open Innovation. Some countries will have a larger supply of innovation spillovers available to firms (whether due to scale or innovation sponsorship). Countries will

differ (due to industrial structure) in the number of firms ready to incorporate such spillovers, with a Japan quite different from the Netherlands or Sweden. Finally, countries differ in the role played by startup companies and thus the importance of venture capital firms, which as Chesbrough (2003a) notes, often serve to disseminate innovative knowledge within an industry.

Building Networks to Support Open Innovation

What conditions would increase the likelihood and effectiveness of Open Innovation strategies? Network attributes have important effects on firm performance (Beckman and Haunschild, 2002). However, prior research suggests that firms cannot assume that "the more network ties, the more innovation".

Here we suggest three factors to consider when using networks as the interface to obtain knowledge in an Open Innovation strategy. Firms need to build ties that are both wide and deep. At the same time, they must also make sure that the value of the knowledge flowing into the company is greater than the value that knowledge outflows provides to potential competitors.

Deep Ties

Gulati (1999; Gulati et al, 2000) argues that a firm's position in a network provides "network resources" that are difficult to imitate and thus potentially provide enduring competitive advantage. If a firm is to obtain innovation advantage through its network position, then its position not only needs to be unique, but it must also tap into key sources (and markets) for innovation.

One way that such uniqueness can be created is through a deep embeddedness in a key technology or market. Firms may do so by locating in densely-populated networks, by building their own value networks, and by strengthening the ties within their networks through building trust. Repeated interactions breed trust in networks (Gulati, 1995a).

Geographic embeddedness. If the effects of network ties on innovation are enhanced by proximity, then firms may decide to establish a physical presence in regions that are repositories of knowledge in their specific industry. High technology firms (such as IBM and Microsoft) have opened branch offices in Silicon Valley to tap into regional knowledge. Intel has created research laboratories near key research universities to facilitate knowledge transfer between the firm and university researchers (Chesbrough, 2003a). Firms that lack geographic proximity to key innovation networks instead must build their own networks, as in switched amplification (Christensen, Chapter 2) or materials science (O'Connor, Chapter 3).

Increasing Tie Strength. Networks of innovation are often based on repeated interactions between firms, and thus depend on trust — particularly in regional clusters where firms and people develop a local reputation based on past interactions. Network forms rely on trust as a coordination mechanism (Powell, 1990).

Limited research has been done on trust and interorganizational relationships. Trust is an important coordination mechanism of networks (Powell, 1990; Uzzi, 1997). Empirical evidence suggests that inter-organizational trust, which is more institutionalized, is longer lasting than the interpersonal trust inherent in informal networks. Trust is crucial in reducing the risks associated with interfirm tie formation (Nooteboom, Berger and Noorderhaven, 1997). Repeated interactions through interpersonal ties can lead to a more institutionalized inter-organizational trust, where organizations come to recognize each other as long-lasting partners and can engage in knowledge exchange ties rapidly (Zaheer, McEvily, and Perrone, 1998).

At the same time, organizations must consider a balance of strong and weak ties when considering their Open Innovation strategy. Strong ties benefit from more institutionalized trust and are likely to be more quickly and easily activated, yet weak and bridging ties provide access to new information which is paramount to innovation. There is an inherent trade-off between trust and novelty, safety and flexibility (Gargiulo and Benassi, 2000). In turbulent environments, Powell and Smith-Doerr (2005) argue that the

linkages are not driven by loyalty but by the need to stay informed, and that proximity leads to greater trust in tie formation. However, Erickson (2005) concludes that the trust between two firms built through past interactions may be reduced through major changes in their respective network roles.

Limitations. Overembeddedness happens when firms rely too much on repeated interactions with the same partners; when these partners are themselves linked through strong ties, the network becomes closed to external information and starts having access to only redundant information, leading to the stifling of innovation (Uzzi, 1997). Indeed, some research suggests that spatial concentration leads to conformity in firm behavior and less innovation (Sorenson and Audia, 2000). Regional clusters, while known for their innovative capacity, run the risk of becoming closed to outside knowledge and becoming overembedded.

Wide Ties

Weak Ties. One way of countering the problem of overembeddedness is to form some weak ties. Since Granovetter (1985) posited the "strength of weak ties," significant attention has been given to the power of arm's length ties. Based on occasional rather than frequent interactions, these ties offer more pathways to new information, because they provide access to different networks and thus different sources of information. Informal professional affiliations such as common organizational affiliation are such weak ties that can be acted on in an Open Innovation model. Weak ties can act as a counter-force to the overembeddedness problem. Little research has applied Grannovetter's (1985) weak ties argument to formal interorganizational network ties, but there is some evidence that firms who combine a mix of strong and weak ties gain more information benefits (Uzzi and Gillespie, 1999b).

Exploiting Structural Holes. Another strategy to avoid becoming overembedded is to exploit structural holes, the gaps between otherwise disjoint networks. Burt (1992) shows that forming

ties to non-redundant, non-connected others leads to more information benefits. Acting as a bridge between diverse actors enables the firm to tap into the knowledge contained in multiple networks (McEvily and Zaheer, 1999).

Diversity of Ties and Institutions. Central to an Open Innovation strategy is to maintain diverse types of ties to a diverse set of institutions. There is a delicate balance between exploration and exploitation ties (March 1991; Koza and Lewin 1998). Exploration in organizational learning involves searching for new opportunities and developing new product or technological development through alliances (Rothaermel and Deeds 2004), whereas exploitation involves capitalizing on existing knowledge and resources. Exploration alliances have been found to predict the future occurrence of exploitation alliances (Rothaermel and Deeds 2004). As the measure of success for Open Innovation is commercialization, the occurrence of exploitation alliances could be used as a dependent variable in the Open Innovation literature.

Each firm has its own appropriate mix of institutions, but these might include universities, other firms with complementary knowledge, government institutions such as research institutes, firms more geared toward commercialization such as venture capitalists, and potentially other professional firms such as law firms. However, it is not enough to connect to a diverse set of partners: firms pursuing Open Innovation also need to utilize diverse types of ties. Formal ties may encompass joint research, commercialization agreements such as licensing, or marketing agreements; informal ties may include labor movements, regional communities of practice, and past common organizational affiliations. When considering the mix of variables — strong vs. weak ties, connectedness and structural holes — research has yet to identify either the optimal mix of variables or the process for achieving this mix.

One value of tie diversity is that innovation often happens through the recombination of sometimes-unforeseen knowledge elements (Smith-Doerr and Powell, 2003), which can be enabled through collaboration between companies. Access to heterogeneous knowledge through networks has increased benefits by increasing chances for recombination leading to innovation (Hargadon and Sutton, 1997; Pelled, Eisenhardt, and Xin 1999). However, some point out that heterogeneity can come at the cost of trust (Hambrick et al, 1996), and there may be a threshold where decreasing returns occur when too many diverse ties are maintained, if they overwhelm the firm's ability to recognize the relevant knowledge in each (Beckman and Haunschild, 2002) and to tie them together to create innovation.

While a firm seeks a diverse set of ties, it has only has a limited set of resources to manage these ties. These limits are particularly important for firms creating global network ties for both its inputs and outputs. Research on multinational ties finds a negative relationship between alliance diversity and performance (Goerzen and Beamish, 2005). For transnational alliances this diversity may be too complex to manage and lead to decreasing returns (Goerzen and Beamish 2005) and structural holes had no beneficial impact (Ahuja 2000), suggesting that tie diversity is most valuable when coupled with geographic proximity.

While so far the research on networks and innovation suggests that firms should concentrate its resources on forming and capturing knowledge from regional network ties, knowledge and markets in the new economy are increasingly globalized, so that successful specialized firms need to tap into knowledge and markets scattered across the globe to rapidly deploy innovative applications (Doz, Santos, and Williamson, 2001). Organizations are part of far-reaching and diverse ecosystems that hold distributed knowledge which is key to one firm's innovation

capacity, and thus "the crucial battle is not between firms but between networks of firms. Innovation and operations have become a collective activity" (Iansiti and Levien, 2004a: 11).

Some firms must manage innovation ties at both the regional and global level due to the nature of their institutional environment. For example, the importance of compatibility standards force telecommunications firms to balance regional supply ties with multinational ties to help them promote their technology in new markets. New research is attempting to measure regional versus global effects: one study suggests firms are less successful if they attempt to maintain centrality in both their regional and global networks, and thus for optimal performance must choose whether to focus on local or global innovation ties (Bunker Whittington, Owen-Smith and Powell, 2004). We suggest that the most appropriate balance between local and global ties in an Open Innovation strategy may depend on the nature of the firm's institutional environment, and thus that the institutional environment needs to be included in analyzing and explaining a firm's practice of Open Innovation.

Technological environments. Different industries have different institutional environments and require different types of tie formation. Hence, in biotechnology, where new knowledge creation and commercialization is heavily based on basic science, research and development ties are the main "ticket entry" through which later commercialization benefits are realized (Powell et all, 1996). By contrast, in industries operating in a technological environment characterized by network externalities (Katz and Shapiro, 1985), there are different strategies of innovation (Sheremata, 2004) and hence different patterns of tie formation. These markets are driven by interoperability standards and the provision of complementary products, as when Qualcomm built ties to promote its technology through standardization bodies and to attract complementary products, which enabled its subsequent licensing business model. However, Qualcomm's

business models depended not only on its ties but its IP strategy (Simard, 2004). Thus, the use of Open Innovation may also depend on the available IP regime both for the industry and desired market (West, Chapter 6).

Maximizing Returns from Knowledge Outflows

Prior research on Open Innovation has under-emphasized the importance of a firm's institutional environment in designing strategy. The network research has, conversely, examined the how firms together form an ecosystem of knowledge flows but has said less about how these may be incorporated into strategy at the firm level. How, then, might we combine the network and Open Innovation perspectives to develop a richer view of the external factors affecting a firm's Open Innovation strategy?

1. Location matters:

The first implication for Open Innovation is that location matters. In some industries and technological environments, forming ties with and establishing a physical presence in a region where important knowledge resides will be key. Thus, a firm may decide to open a branch close to a partner or competitor that to attempt to establish knowledge spillover benefits, as when large telecom firms established a presence in San Diego to tap into Qualcomm's CDMA knowledge. Firms may also locate in proximity to an elite university where partnerships with faculty and the hiring of top students can become crucial for the firm to keep abreast of cutting edge scientific knowledge in a field, as has been documented in the biotechnology industry (Porter, Whittington, and Powell, 2006).

2. The Learning Race: maximizing returns from spillovers

In any firm, key knowledge will spillover from a firm to its customers, suppliers, partners and competitors. Strategies and mechanisms that enable inflows of key knowledge — such as building a broad and deep network and locating in a dense cluster with high labor mobility — can also enable a comparable outflow of knowledge. Even in formal alliances for learning and sharing information, the complementary stocks and deficits lead alliance partners to a "learning race" (Hamel, 1991; Gulati, Nohria, and Zaheer, 2000), whereby one organization tries to maximize its learning from the other and minimize the amount learned by the other while trying to retain trust. Khanna et al (1998) show that firm learning expectations predict resources allocated for learning, and thus learning success.

The response of the traditional innovation model is to clamp down on such flows, by segregating access to knowledge, locating away from dense networks of suppliers and competitors, and attempting to minimize job turnover. This has been the inherent approach of large U.S. European and (especially) Japanese multinational companies. But such an approach also cuts a firm off from finding markets for its technologies and often impedes the flow of inbound innovation as well. But if firms are unwilling or unable to be part of a network, they may be a disadvantage compared to those firms that gain knowledge and increased innovation capacity by belonging to such networks.

Another approach (as recommended by Chesbrough, 2003a) is to adopt an IP strategy that allows and encourages the outward flows, but maximizes the economic returns that accrue from commercial application. Instead of using trade secrets to keep the ideas within the firm, a firm would aggressively patent its ideas and disseminate them widely, assuring a stream of patent royalties should those ideas be adopted (O'Connor, Chapter 4). At the same time, such strategies

are increasing the cost of inbound flows of external innovation, as when universities seek to profit from publicly sponsored research that they once would have allowed to spillover to local firms (Fabrizio, Chapter 7).

Where patents are ineffective, firms can develop polices to license their tacit knowledge and thus actively participate in the success of its spillovers. Such policies both accelerate commercialization of the innovation and also provide the recipient with an advantage over potential rivals. For example, when Xerox PARC declined to exploit key inventions and was faced with the likely defection of key scientists seeking to commercialize these inventions, it developed a range of policies to allow Xerox to participate in the commercial success of any spinoff companies (Chesbrough, 2002).

Firms may also differ in their knowledge-sharing intensity with different partners. That is, some collaborations or alliances can be identified as particularly crucial to a firm's innovation. In that case, the firm may decide to maximize knowledge exchange by establishing more open knowledge-sharing routines in order to maximize absorptive capacity (Dyer and Singh, 1998). Dyer and Singh argue that knowledge transfer and absorption are maximized by processes that maximize social and technical interaction between the firms, such as sending employees at the other firm and repeated interactions.

Finally, approaches to maximizing the returns to spillovers need to recognize the role of both formal and informal ties carrying knowledge away from the firm. Business models are more likely to be successful if they acknowledge the existence of informal ties and spillovers that cannot be stopped, by assigning a price to essential knowledge that can be protected and is an essential complement to the free spillovers. For example, I.T. systems vendors widely disseminate knowledge about building complements that increase the value of the firm's

products, but aggressively protect the information necessary to build competing implementations via trade secret, patent and often copyright law (West, 2006).

3. Building an Open Innovation network

In Figure 11.1, we consider the trade-offs between two dimensions of network ties identified above: deep vs. wide ties and formal vs. informal ties.

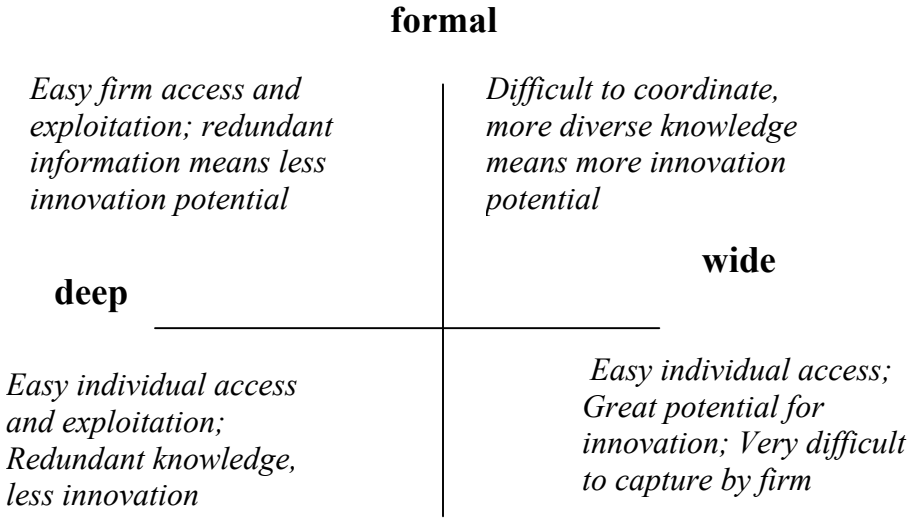

Figure 11.1: Nature of interfirm ties enabling Open Innovation

Deep networks are easily activated and the knowledge contained in them easily captured, however the knowledge contained in these networks is likely to be redundant with knowledge already possessed by the organization. This trust and access to knowledge is further enhanced by geographic co-location. The potential for the networks to increase innovation is thus comparatively small; one hypothesis would be that deep networks tend to lead to incremental innovation as opposed to radical innovation. When ties are deep and informal, they also provide the potential for easy access to information but add another challenge for the firm that needs to

recognize and act upon information hidden in the fabric of employees' social lives. Such informal ties, while an extremely important part of the knowledge flowing into and out of the firm, would be difficult to predict and incorporate into an explicit Open Innovation strategy.

Wide ties provide the benefit of access to non-redundant information and thus a greater potential for innovation, but without the trust inherent in deep ties. Wide ties are also hence more difficult to manage, particularly in capturing and re-combining these sometimes disparate information elements into new knowledge. The coordination and trust difficulties are further compounded when there is an absence of geographic co-location. Wide networks of informal ties have high potential value for knowledge creation, but pose significant challenges in managing the inward and outward knowledge flows to maximize firm benefit. Again, a major role for informal ties makes it difficult to predict, capture and plan the role of such ties, but this does not mean that they can (or should) be ignored.

The need for firms to balance the need for deep and wide ties parallels the need identified by Tushman and O'Reilly (1996) to balance short-term and long-term technological change. They contend that firms require an "ambidextrous" capability to cope with incremental and radical innovation. Consistent with Tushman and O'Reilly, we would expect that wide ties would be necessary to cope with new technological trajectory (per Nelson and Winter, 1982), while deep ties would be needed to strengthen innovative capabilities within a given trajectory.

Implications for Future Research

Open Innovation is about harnessing knowledge flows across firm boundaries (Chesbrough, 2003a). The channels for these repeated flows are interorganizational networks, constituted from a diverse range of possible ties. Each tie may vary in strength, the enabling mechanism, the level of analysis, and the direction of knowledge flow that it provides. And the portfolio of network

ties managed by firms may differ in the breadth and depth of the knowledge they collectively provide, and in the geographic locus of the network partners.

Thus the study of the role of network ties in innovation is implicitly (if not explicitly) one that relates to potential Open Innovation. Here we identify opportunities for future research about the relationship of knowledge flows, interorganizational networks, geography and the practice of Open Innovation.

Understanding Informal Ties

Studies of networks in innovation have emphasized the role of formal ties at the organizational level, but the role of informal ties is less well understood. These informal ties may be those that arise from formal alliances and other ties (and thus reflect an unmeasured confound), or they may be those ties utilized by a firm's employees in a way that may not be a visible part of the firm's strategy.

Similarly, while research on Open Innovation has emphasized formal institutions, the framework should also consider how commercially valuable knowledge can be accessed through informal networks. Firms can and do exploit informal knowledge flows, by hiring the best possible sources of knowledge – individuals with not only strong backgrounds but from companies or industries on which the organization wishes to gain knowledge. Firms seeking to capture external innovation through informal ties will seek to employ not only the ones with the most knowledge in specific areas, but also the ones with past career affiliations to firms that act as repositories of knowledge in specific areas.

The benefit of formal and informal ties comes from inbound flows of commercially valuable knowledge. But the existence of a tie is not a guarantee of knowledge transfer; a key moderator is the level of trust by the disclosing party. Trust may also play other roles in interorganizational

networks, such in a willingness to form ties and the ability to interpret tacit knowledge to unlock its latent value. And in at least some forms of networks (such as interactions with universities, open source communities or other nonprofits), efforts to realize commercial value from knowledge flows can potentially reduce the trust that enables such flows.

At the same time, both formal and informal ties have their costs —the direct costs of managing the ties and as well as the potential indirect costs if the knowledge provided obtained by the firm is less valuable than that which flows out to competitors. The trade-offs are likely to differ greatly according to institutional context, depending on the social fabric of the industry or geographical cluster in which the firm is located.

For example, recent research suggests that formal networks in the biotech industry may be more open and more conducive to innovation than informal networks which are more closed. In the case of biotechnology, informal social networks tend to be clustered around star scientists who act as a bottleneck for information sharing (Porter, Bunker Whittington and Powell, 2006).

So what are the industry, regional, firm and individual factors affecting both a firm's efforts to create a mix of formal and informal ties, and also the value of that mix for Open Innovation? Are there commercialization benefits that extend across industry and institutional contexts? Or is the relative role of such ties primarily due to a firm's technological, economic and geographic context?

Managing the Network Portfolio

Rather than a single tie, the interorganizational networks of innovative firms will include a portfolio of complementary ties. Firms thus must determine what individual ties best support their innovation strategies, what interaction effects they are (positive or negative) between the various ties, and how to maintain and improve the overall portfolio.

The individual ties can vary across numerous dimensions: formal vs. informal, strong vs. weak, local vs. national vs. international, and individual vs. firm level interactions. Within the within the formal vs. informal dimension, a range of mechanisms for creating ties exist, including formal R&D alliances, arms length licensing, or (on the informal side) harnessing employee coworker networks. Each tie can also support inbound knowledge flows, outbound flows, or some combination thereof.

There are additional issues to consider when valuing a combination of multiple ties — whether the whole is more or less valuable than the sum of the parts. Firms can choose to develop wide or deep ties, and a high or low level of diversity in tie dimensions and mechanisms. Prior research has implied there are trade-offs and a possible U-shaped relationship for each.

There is also potentially an interaction between firm size, level of integration and use of external ties. As part of an Open Innovation strategy, a small firm is likely to build deep and lasting ties to integrate its particular business model into a larger value network. However, large firms — particularly vertically integrated ones — may be tempted to develop in-house (or acquire) its own deep knowledge in areas that play an important role in supporting its business model; this would fit the fundamental idea of a core competence, as discussed by Christensen (Chapter 3). One would expect both types of firms to use weak ties to find new knowledge that they didn't even know they needed — but these hypotheses are all testable propositions.

Thus, there are numerous unresolved questions regarding the role of these network portfolios in promoting Open Innovation, including balancing the trade-offs on each dimension, the influencing of external factors in determining the available tie options, and the optimal tie mix (moderated by internal and internal factors) to maximize knowledge flows that support innovation.

There is also the question of the direction of causality. Chesbrough (2003a) focuses on examples where firms have successfully implemented Open Innovation strategies. But does each firm have an endogenous set of choices for building its network portfolio? Or are the tie options (particularly for younger and smaller firms) sufficiently constrained that the network portfolio drives the innovation strategy? Are there particular aspects of the network portfolio that would significantly raise (or lower) the effectiveness of Open Innovation as part of the firm's innovation strategy?

Geography and Innovation Networks

Considerable research has shown that geographic proximity facilitates network formation. Such proximity can identify partners for formal ties such as agreements to license technology or supply key components. It can also allow firms to better utilize the value of informal ties, as when a biotech firm hires the alumni of the local research university both to identify potential partners at the university and provide entrée for future collaboration.

Regional clusters can provide an ideal setting to study Open Innovation: start-up firms in technology intensive industries cannot spend the time and resources to build their own fully integrated innovation funnel as the old model of innovation implies. Rather, these companies can rapidly form network ties to institutions and firms with complementary knowledge in order to bypass the innovation funnel and be first to market.

At the same time, firms cannot limit their search for innovation sources or markets to a subset of desirable partners. So it remains an open question whether firms embedded in regional networks practice more Open Innovation that those more geographically distant, or whether other factors determine the openness of innovation.

At the opposite extreme, metanational firms increasingly seek to capture specialized knowledge in different parts of the world (Doz, Santos, and Williamson, 2001). Are Open Innovation practices across national boundaries different from those within a nation-state? Do factors that would attenuate tie strength — e.g., measure of cultural distance such as language (West and Graham, 2004) — also apply to tie formation or knowledge flows within ties? Do such factors have a greater impact on informal than formal ties?

Finally, there are interaction effects for both regional and global influences on open networks. Are regional innovation ties more important for early stage industries (or those with rapid rates of technological change or new firm formation) than for more mature, slowly-changing industries. Conversely, for industries with globally dispersed specialized knowledge, does Open Innovation success depend on a competency in creating, maintaining and utilizing such cross-national innovation networks (cf. Dedrick and Kraemer, 1998).

Measuring Innovation Creation and Flows

Understanding the role of external innovation and opportunities to commercialize internal innovations requires, in turn, an understanding of the firm's interorganizational knowledge flows. Measuring such flows remains a challenge, whether they are to be used as an antecedent, mediator or outcome of the firm's level of innovation.

Patent data is often used as a measure of both innovative output and (through citation analysis) of the relationship between individual inventions. Such data is readily available, corresponds to a population of a particular type of innovation (patented invention), and use of allow rigorous statistical techniques. One important impact is that they provided an externally relevant measure of invention influence through citations of prior art.

However, as Gallini (2002: 138) notes, "patent counts are an imperfect measure of innovation." For example, the patent propensity of some industries is comparatively rare, while in other industries patents are used for defensive purposes.

More fundamentally, patents measure technological invention, the outcome of a process of knowledge generation. Open Innovation draws the distinction between a technology and realizing the commercial value of that technology, as mediated by the business model (Chesbrough and Rosenbloom, 2002; Chesbrough, 2003a). Assuming that the latent economic value of all patented inventions can be realized assumes away the role of business strategy, complementary assets, and all the other factors identified by Teece (1986) to appropriate the value from a technology; we know from prior research that firms can and do differ dramatically on such dimensions.

Ideally, Open Innovation research would both measure technological innovation (such as though patents) as well as the commercialization of that innovation. Examples of the latter would include annual licensing revenues, new product development and market share of new products; many of these measures have been used, although there are often very difficult to obtain for a wide range of firms in a given industry.

Finally, Open Innovation presumes knowledge flows between firms. Patent citation counts have been used as one measure of such flows, but as Jaffe et al (2000) report, they are only partially correlated to self-reported knowledge flows, which suggests at least one measure is an imprecise measure. In other cases, network studies often assume that knowledge is flowing through ties without investigating the type and content of knowledge in these ties (Simard, 2004). Measures exist for some forms of knowledge utilization across formal ties — such as licensing agreements and royalty payments. But flows across informal ties are inherently harder

to measure, and without such measures it would be impossible to analyze the relative importance of formal and informal ties — as well as the antecedents of such knowledge flows (such as industry or firm characteristics) and their consequences (i.e. whether the flows lead to innovation). Such processes could be studied through comparative case studies.

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End Notes

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[i] A "bright line" test is one that provides "an unambiguous criterion or guideline especially in law." (*Merriam-Webster Collegiate Dictionary,* 11th ed.), analogous to the bright lines displayed in a spectrograph.

[ii] We don't mean to suggest that networks have completely supplanted vertical integration. Examples where the latter remain desirable include controlling downstream markets for innovation (Chesbrough and Teece, 1996), or obtaining an upstream supply of crucial innovation (Podolny and Paige, 1998).

[iii] Social capital is understood here not in the sense of civic participation theorized by Putnam (1993), but instead as the structural and relational assets created by interpersonal relationships (Tsai and Ghoshal, 1998).

[iv] Instead of "star" organization, Feldman (2003) allows for multiple "anchor tenant" firms, analogous to shopping malls; her study does not examine the case of anchors entering, exiting or changing in relative importance.