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Social Networks for Innovation and New Product Development

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In this article we first provide a brief introduction into social network analysis, focusing on the measures and approaches that are used in the empirical contributions in this special issue. Second, we discuss the role of social networks in new product development. Social networks are inherently multilevel; we consider four "levels": networks inside a firm, networks that cross firm boundaries, networks between firms, and networks that reside outside of the firm. Third, we discuss these four levels and highlight some of the extant research. We summarize and position the eight papers in this special issue along these four levels. Together, we argue, these papers provide an interesting coverage of this burgeoning field.

Introduction

Innovation is, by necessity, a collaborative effort. Existing knowledge and ideas merge into new combinations, and as formerly separated knowledge comes together, new knowledge emerges.

Studying what happens when diverse knowledge is combined and innovations emerge can be done in largely two different manners. One is by focusing on the content of what is being combined. This approach is one in which qualitative analysis prevails. The extent to which the findings are context-, or more specifically (knowledge) content-specific can be high. Extrapolating findings to other contexts and contents can be problematic.

Another approach is to focus on the structure of the contacts between those who bring the knowledge together, who exchange knowledge. This approach often entails social network analysis. Social network analysis, as we discuss in the next section, suggests that the position in a networked structure of exchange goes a long way in determining how the process of exchange develops and what the outcomes of the exchange will be.

Much is already known from social network analysis about the collaboration of people, how they interact and exchange, mostly based on research conducted in contexts different from innovation and new product development. The innovation and new product development context, however, can be different due to its inherent larger ambiguity, uncertainty, and reduced possibilities to act in routinized ways. The question, therefore, is which of these results from previous studies apply when studying innovation (Borgatti and Halgin, 2011). It is very likely that the future will see many more studies of innovation and new product development that are inspired by insights and methods from social network analysis.

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Social Network Analysis

A network is a set of actors connected by a set of ties. Social networks are social constructions arising from exchanges and joint activities among participants in a social system. These participants are often called "actors" (or "nodes" or "vertices") and can span several levels of analysis: individuals (e.g., individuals in a new product development team), teams (e.g., teams working together in a project), formal organizations (firms in a market), coalitions (e.g., lobbying alliances), or even regions and nations (e.g., members of the World Trade Organization). Actors can even include digital repositories, ideas, concepts, product modules, technical solutions, etc. Ties (also called "edges") connect pairs of actors and can be directed (when there is a sender and a receiver and thus a directed flow; e.g., giving advice to someone) or undirected (e.g., being colocated), and can be dichotomous (e.g., whether two firms collaborate or not) or weighted (e.g., the intensity of the collaboration among two firms). Ties can vary in content, with each content essentially defining a different network (e.g., the "resource-sharing network" is distinct from the "advice-giving network," although empirically they might be correlated). It is important to be explicit about which type of tie is studied: a firm that has many "knowledge-sharing" ties will find itself in a position that is very different from a firm with many "who-sues-whom" ties.

Research needs not be limited to a single substantive relation. Most network studies focus on one type of tie, usually informal ties (Reagans and McEvily, 2003).

Often, multiple substantive ties exist among the same set of actors, a phenomenon known as "multiplexity" (Hansen, Mors, and Løvås, 2005; Ibarra, 1995). For example, a multiplex relation between two members of an innovation team exists when they have a knowledge-sharing tie and a friendship tie. Multiple networks can usually be defined among the same set of actors, and the extent to which the ties overlap can have an important effect on these actors (cf. Aalbers, Dolfsma, and Koppius, 2014; Soda and Zaheer, 2012). For example, team members who share knowledge and consider each other friends may be more likely to share knowledge in the future as well, compared with two team members where the friendship is lacking or conflicts may occur.

One type of tie can enhance another type of tie. For example, trust or friendship relationships may motivate knowledge-sharing or the start-up of a joint collaborative project. Sales persons often enhance/"multiplexify" their sales interaction with prospective customers with friendly, nonwork-related activities, in the hope that the friendship tie may encourage a business transaction. Research has shown that combining friendship and business in the same relationship can be beneficial; but it can also create conflict (Grayson, 2007).

An important characteristic of a network tie is whether it is reciprocated or not: does a tie only go from *A* to *B*, or is there also a tie from *B* to *A*? Reciprocity is often considered a sign of relational strength: when two parties both report a tie to the other, the tie is likely to be more impactful than when only one party considers the tie to be there.

When considering a single or specific actor (and its network ties), this actor is commonly referred to as "ego" and the actors that ego is tied to are commonly called ego's "alters." The collection of an ego, ego's alters, and the ties among all of them is called ego's "ego-network." Alternatively, when studying an entire network as a whole, one often refers to the network as the "total network" or "whole network."

Networks can be depicted in several ways, the most common are as a network figure or as a sociomatrix. Figure 1 shows a hypothetical social network (modified from Knoke, 1999) of a new product development (NPD) team and a production team. The sociomatrix (top left) is a matrix in which cell (i, j) has value 1 if a tie from actor i to actor j exists, and 0 otherwise. A figure of the network in Figure 1 shows the nodes as circles and the directed relations as arrows with arrowheads showing the direction of the tie. When analyzing a social network, researchers often study the relational patterns that reside in them. For example, the network *volume* is the total number of ties among the actors in the network, and the network's *density* is the proportion of observed ties to the number of possible connections (not counting the potential ties from actors to themselves). The network in Figure 1 has a volume of 16 (which can be seen by counting the arrowheads in the graphic or counting the 1s in the sociomatrix) and a density of 16/56 = .29 (which means that 29% of all possible ties actually exist in this network). Actors typically differ in the number of ties they maintain; an actor's *indegree* counts the number of ties from ego's alters to ego, whereas the *outdegree* counts the number of ties emanating from ego to its alters. In Figure 1, actor A has an indegree of 4 and an outdegree of 3. A prominent term in social network analysis is *centrality*, a term that has immediate intuitive attractiveness, but that has been defined in a great many different ways. If one considers the *shortest paths* (i.e., the minimum number of steps that are needed to "walk across the network" from one actor to another) between any pair of actors, an actor's *betweenness centrality* is defined as the number (or proportion) of all shortest paths in the network that the specific actor is on. When considering knowledge flow networks, actors with higher betweenness centrality have an important information availability advantage over the other actors: they will likely have more timely and more complete information access than actors with lower betweenness. In addition, such high betweenness actors have the potential power to act as gatekeepers and (consciously) obstruct,

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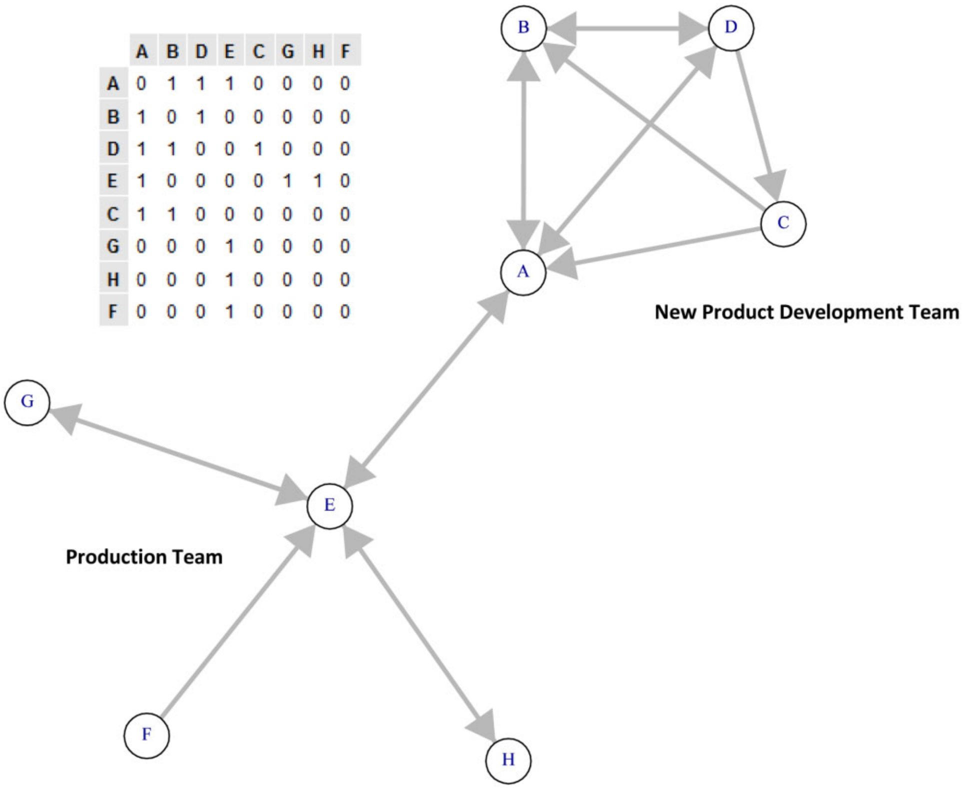

	A	B	D	E	C	G	H	F
A	0	1	1	1	0	0	0	0
B	1	0	1	0	0	0	0	0
D	1	1	0	0	1	0	0	0
E	1	0	0	0	0	1	1	0
C	1	1	0	0	0	0	0	0
G	0	0	0	1	0	0	0	0
H	0	0	0	1	0	0	0	0
F	0	0	0	1	0	0	0	0

Figure 1. Hypothetical Knowledge and Information Sharing Network

mediate, or facilitate knowledge flows from one actor to another. In this example, E has the highest betweenness centrality (24 out of 56), closely followed by A, whereas F, G, and H are not on a single shortest path. This means that E and A are at the heart of the knowledge flows in this network, and that F, G, and H are likely to receive knowledge and information the last or the least. When E or A becomes sick or moves to another team, the knowledge flow among the members of these two teams will become seriously hampered; this risk is negligible when H or B leaves the team. A related type of centrality is "closeness centrality." Again starting from the shortest paths among all pairs of actors, the closeness centrality of a specific actor is defined as the inverse of the sum of the lengths of the shortest paths between the actor and all of the other actors. In other words, the lower the total distance from all other actors, the more central the actor. Whereas betweenness centrality focuses on the extent to which an actor is between others and is an intermediary on likely knowledge streams, closeness centrality measures the extent to which an actor is located near the center of the network.

For further detail and discussion of additional social network analysis techniques and their use, one could refer to textbooks such as Knoke and Kuklinski (1982), Wasserman and Faust (1994), Hanneman and Riddle (2005), Kolaczyk (2009), and Aalbers and Dolfsma (2015).

Social Networks and Innovation

Although the imagery of the lone inventor developing new profound technology is appealing, it is an image rarely found in modern times. Innovation is a "team sport," where individuals work together in teams, teams work together in projects, organizations work together in alliances, and countries work together in international technology agendas. In fact, even the mythical lone inventor probably was not operating in splendid isolation anyway, since it is likely that much of the inventor's inspiration came from interaction with other people or organizations, the financial resources may have been granted by banks or friends, the actual development of the product often involved the help of factories, and customers had to become involved in order to test the product for feasibility. No matter which (great) invention one would look at, it is bound to be couched in network interaction of some sort.

The many books on James Watt's contributions to the steam engine often tell of Watt's moment of epiphany

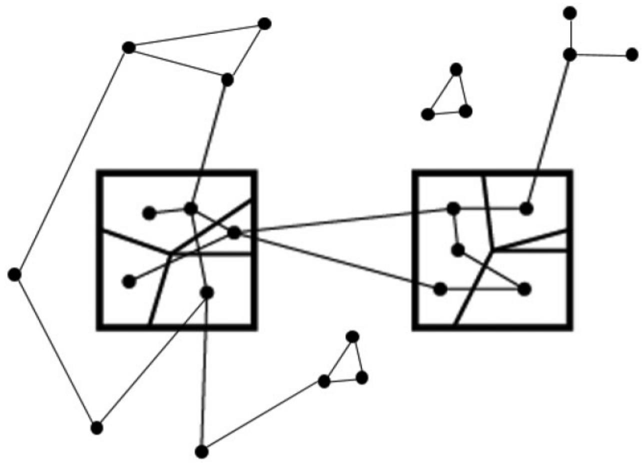

Figure 2. Networks Within, Between, and Around Organizations

when he conceived of the idea of a condenser for Newcomen's engine. But a closer look reveals a social network surrounding the inventions of James Watt and his partner Matthew Boulton, connections among inventors, scientists, and institutions (Moon, 2014). The extensive study by Moon (2014) shows how social networks connected to the work of inventors like James Watts and Leonardo da Vinci, and how these networks helped shape the development of early automobiles and aviation, wireless and radio electronics, air conditioning, and clocks. Similarly, although Thomas Edison cherished his image as a lone genius, his greatest invention may have been the invention factory itself (Hargadon, 1998); in fact, Edison is now sometimes referred to as a "collective noun" rather than a single individual (Millard, 1990). The bottom line is that social networks are essential to new product development, and that the understanding of NPD can be deepened by involving social network aspects.

Social networks are inherently multilevel and can include nodes that vary from single individuals to nations and geographic regions. In this special issue, we distinguished four "levels" of analysis—networks within organizations, networks that cross the boundary of the organization, interorganizational networks, and networks surrounding the organization (e.g., networks among customers). Figure 2 gives a graphical representation of the multilevel character of real-life networks: members of organizations—the squares in the figure—are connected among themselves, have boundary spanning ties with their environment, and the actors in that environment are also connected. This introduction briefly discusses each level and introduces the articles that reside at each respective level.

Intraorganizational Networks and Innovation

NPD efforts are typically executed in a project-management approach, with the NPD team as the organizational nucleus. The innovative performance required of NPD teams is driven by the communication structure of the team (Allen, 1971, 1977; Hoegl and Gemünden, 2001; Katz, 1997; Leenders, Van Engelen, and Kratzer, 2007). NPD teams are information-processing units; like individuals, teams process information by encoding, storing, and retrieving it (Brauner and Scholl, 2000). Through effective communication, building on the knowledge of others, team members exchange information and create new knowledge and insight (Reagans and Zuckerman, 2001). The team's innovative ability is greatly enhanced by appropriately coordinated communication among members of the team.

In their seminal study of how the patterns of communication among the members of research and development (R&D) projects affect the technical performance of R&D labs, Katz and Tushman (1979) show that research projects benefit from a high degree in both the intraproject problem solving and administrative communication networks, whereas intense interaction in the administrative communication network has a negative effect on the performance of technical service projects. For their research, Katz and Tushman asked each of 350 respondents (across 61 R&D projects) to specify those individuals with whom the respondent had oral communication on a particular day. These sociometric-type data were collected on randomly chosen days each week for a period of 15 weeks (Katz and Tushman, 1979).

In a related study of how R&D project performance is affected by the social networks of project members, Hansen (2002) collected data from a multidivisional electronics company and asked the R&D managers in 41 divisions and the project managers of 120 projects that were executed within these 41 divisions about the interdivisional knowledge-sharing contacts within the company. Hansen asked each of the respondents to indicate which of the other 40 divisions the respondent's division had regularly sought technical and/or market-related input from, over the past two years—he followed this up by asking which of the other 40 divisions had asked the respondent's division for this type of input. Hansen was especially interested in whether it mattered if the interaction maintained by a project team was with other divisions that possess related knowledge for the team's project or with other divisions that primarily worked with unrelated knowledge. Hansen's main finding was that projects in divisions with short network path lengths (i.e., high closeness centrality) to other divisions that possessed related knowledge obtained more knowledge and were completed faster. The stronger the ties to related divisions, the more ties to related divisions, and the shorter the paths to related divisions the faster projects were completed. Ties to divisions with unrelated knowledge had no such effects.

Whereas the work above mostly focuses specifically on direct project-related communication, Allen, James, and Gamlen (2007) focused on informal knowledge networks and found it to differ significantly from the formal structures put in place by the company to manage knowledge transfer. Studying the informal networks in the R&D function of ICI, a large multidivisional chemicals company, they found technical personnel to engage in interaction most frequently with those in close organizational and geographical proximity to them, rather than with colleagues located in other ICI businesses or regions—formally prescribed memberships of various collaborative and knowledge-sharing structures resulted in little collaboration on problem-solving issues (Allen et al., 2007, p. 193).

In this special issue, Aalbers, Dolfsma, and Leenders (2015) present a case study of five new product development projects. They focus their analysis on the ties that project teams maintain throughout the company (to other teams or to management), and study whether these external ties support the innovative performance of the teams. Their findings suggest that the team's ability to benefit from external ties depends on the way in which the team organizes its own networking activity, although project teams that perform well tend to have more external ties in general and ties to management in particular. However, they find that these ties should be concentrated in the hands of a few team members only, so that the external networking activity becomes a specific task for some team members, but not for others.

Innovation Networks Crossing Organizational Boundaries

Just like the lone inventor has become an image of the past, innovating organizations rarely go it alone either. Organizations involve a large variety of partners in their NPD process—such as users, customers, suppliers, distributors, intermediaries, and even competitors—and engage in a varied set of collaborative arrangements—such as alliances, joint ventures, collective research, codevelopment, informal networking, competitions, co-opetition, etc. As a result, companies increasingly shift from innovation activities that are centered on internal resources ("firm-centric innovation") to those that are centered on external networks ("network-centric innovation") (Nambisan and Sawhney, 2011). These collaborations form an *ego-network* with the organization as the ego. There is ample evidence that ego-networks can have a profound effect on a firm's innovative performance. For example, in a longitudinal study of 77 telecommunications equipment manufacturers, Phelps (2010) found that technological diversity in a firm's NPD alliance network positively impacts the firm's exploratory innovation. In addition, the higher the density of the network among the firm's partners (i.e., the higher the extent to which the firm's partners are also alliance partners among themselves), the stronger this effect of diversity; this moderation effect is likely to occur due to the increased trust, joint problem-solving efforts, and improving knowledge detection and transfer from and between the firm's diverse partners, which are associated with high density innovation alliances networks.

Whereas there is ample research on the interplay of innovation and interfirm networks and also quite a bit of research on intraorganizational innovation networks, research that explicitly focuses on network ties that connect the inside of the organization with its outside (e.g., ties between internal NPD teams and external potential customers) is quite scant. This is surprising, because successful innovation often requires firms to get knowledge, ideas, financial, and other resources from "the outside" and bring them into the firm, where they need to be routed to the right place at the right time. In other words, successful innovation requires firms to maintain both an effective arrangement of external ties and a smooth internal network that allows the firm to integrate the externally acquired knowledge into its own process and that feeds the external ties with input from the firm itself. From this point of view, part of the literature considers firms as "knowledge brokers": firms seeking strategic advantage by gaining access to a variety of industries, exploiting their network ties to learn about a wide range of existing problems and solutions, and creating innovative solutions in the form of new combinations of these existing ideas (Hargadon, 1998)—firms such as IDEO, Hewlett-Packard, Boeing, and McKinsey.

Some firms are markedly better at building, maintaining, and exploiting effective networks. Sivadas and Dwyer (2000) argued that some firms are simply more competent at cooperation than are others and that this "cooperative competency" can explain new product success. Ritter and Gemünden (2003) studied a sample of 308 German mechanical and electrical engineering companies, focusing on their network competence. They found that the competence of a firm to manage its technological network allows it to intensively involve others in their technological development process. In addition, network competence was also found to be positively related to the firm's innovation success, above and beyond their own internal technological competencies. In fact, Gulati, Nohria, and Zaheer (2000) pointed out that the structural pattern of a firm's relationships can be an inimitable resource; in order to exploit the potential for innovative competitive advantage embodied in their network ties, lead firms should manage the structure of their networks carefully. In a longitudinal study of 49 firms who were competing to set two technology standards, Soh (2010) demonstrated that, during the race to define a dominant design, firms that networked cleverly were able to force their preferred dominant design over that preferred by competitors. He showed that firms benefit from positioning themselves more centrally than others; this helps them attract suppliers of complementary products and turn market resources away from competing standards. High network centrality is beneficial when participating firms within the same technological community have a strategic intent to acquire and share knowledge broadly, and common standardization goals are widely acknowledged and promoted. The clever networking of such firms should increase the incentive of potential suppliers and buyers to invest in their standard (Soh, 2010).

In this special issue, the article by Lynch, O'Toole, and Biemans (2015),, as well as the article by Schleime and Faems (2015), deal with social networks at the intersection of the firm and its external environment. Schleime and Faems focus on the impact that intrafirm networks have on the success of collaborative endeavors the firm engages in. Their findings suggest that both intrafirm and interfirm collaboration increase NPD performance, but that this mainly occurs in the case of incremental innovation. When the NPD project is aimed at radical innovation, a trade-off between intra- and interfirm collaboration kicks in, effectively canceling their joint positive effect. Overall, the article suggests trade-offs to occur between interfirm and intrafirm knowledge flows, which might have implications for the way firms manage their collaborative (radical) NPD activity.

The contribution by Lynch et al. (2015) focuses specifically on the collaboration between firms and their customers. Although there is ample literature on the involvement of customers in a firm's NPD activity, the actual ego-network that results from such involvement has rarely been studied systematically. The authors propose a series of metrics that capture important characteristics of this network. The metrics address the antecedents of the firm's ego-network (e.g., the firm wanting the customers to contribute to idea screening or product testing), the structure of the ensuing network (e.g., range, tie longevity), and the way in which interactions occur (e.g., frequency and intensity of the interaction and the organizational level at which the interaction takes place). The proposed metrics can guide future research on firm–customer interaction to focus on a specific set of variables that distinguish one customer network from another and that can help explain how and why one firm can employ its customers more effectively in NPD than can others.

Interorganizational Networks and Innovation

There is an abundance of network studies at the interfirm or industry level (Zaheer, Gözübüyük, and Milanov, 2010). Network ties among firms have been argued to stimulate trust, knowledge flow, flow of ideas, and innovative culture (Phelps, 2010). Sometimes organizational networks are located in specific regions, with Silicon Valley (California), Bangalore (India), Digital Media City (Seoul, South Korea), Eindhoven (the Netherlands), or Tel Aviv (Israel) having an exceptionally high density of tech start-ups in the world. What makes such regions work is the network activity among the firms; without their interconnecting, it would be unlikely for such regions to be (and remain) truly innovation hotbeds (Ozcan and Eisenhardt, 2009).

The prevailing finding is that interfirm networks are conducive to innovation because they give firms access to diverse knowledge and help them to, jointly, combine complementary resources (Dyer and Singh, 1998; Gulati and Gargiulo, 1999; Ingram and Roberts, 2000; Phelps, Heidl, and Wadhwa, 2012; Reagans and Zuckerman, 2001; Soh, 2003).

Rampersad, Quester, and Troshani (2010) investigated how interfirm innovation networks can be managed and their outcomes affected. Drawing on data from Australian high-technology networks in information and communications technology and biotechnology/nanotechnology, they found evidence for the impact of power distribution, trust, coordination, and harmony on achieving network outcomes. However, the specific relationships among several of their variables varied per industry, suggesting that much is still unknown about the functioning of alliance networks as a whole.

Besides long-lived alliance networks that exist for innovative purposes, but not necessarily for a specific innovation, many interorganizational networks are set up specifically to produce a single innovation (or a set of related innovations). Here, organizations come together in a project-like manner, with (largely) predetermined outcomes in mind and clear joint goals. Kratzer, Leenders, Van Engelen, and Kunst (2007) describe the case of a world-leading diaper manufacturer that established an innovation network that included itself and its suppliers, customers, and logistics partners, with the intention to develop innovations that would benefit the entire chain.

In an in-depth study of the functioning of an international innovation network within the space industry (set up to develop satellite-based measurement instruments), Schönrok (2010) investigated how communication and knowledge-sharing ties emerged and vanished among the partners. Task interdependence (when coupled with proficient task decomposition) strongly guided knowledge-sharing and coordination communication. An interesting finding in her study is that the factors that are often reported to govern intraorganizational communication and knowledge-sharing do not necessarily carry over to the project/interorganizational network level. This suggests that research at both levels of analysis is needed (and research that crosses these levels).

In this issue, Gilsing, Cloodt, and Roijakkers (2015) investigate the evolution of a technology-based interfirm alliance network in the biopharmaceutical industry over about 25 years. Their focus is on two ways in which the embeddedness of a firm in a network can be understood: "structural embeddedness" (relating to the extent to which a firm can gain access to resources owned by organizations it is not directly connected to) and "positional embeddedness" (referring to the benefits a firm accesses through its network position—such as being more or less central). A main finding is that the progression of network embeddedness is not linear throughout all industry development stages, which implies that the value of a network neither remains constant over time, nor does it change linearly. This not only generates nuance vis-à-vis prevailing theory, it also suggests that managers may need to think differently about their firm's network activity than has been suggested so far in the literature.

Networks and Innovation in Markets

At the highest level of aggregation, one would consider networks that live beyond innovating organizations per se. Usually, these are networks of individuals, ranging from inventor networks to networks of customers or users. With the strengthening of the open source model, many user networks have become powerful innovators, but exactly how user networks shape innovative outcomes has largely remained unexplored (cf. West and Bogers, 2013). Some of these networks are created fully by users themselves, such as the networks that develop(-ed) Linux, Wikipedia, Rodeo kayaking, or the statistical software R. Others are instigated by companies that hope to draw ideas and inspiration from them—examples include LEGO, Akzo Nobel, Unilever, and Beiersdorf Pearlfinder. The ways in which such networks are "organized" include, among others, webforums, competitions, crowdsourcing, or open innovation. Here, we are particularly interested in the networks that are built by and maintained by individuals.

User innovation networks bring a great advantage to users over manufacturer-centric innovation in that they enable each user to develop exactly what it wants rather than being restricted to available marketplace choices or relying on a specific manufacturer to act as its (often very imperfect) agent. Moreover, individual users do not have to develop everything they need on their own: they can benefit from innovations that are developed by others and are freely shared within and beyond the user network (von Hippel, 2007, p. 294).

There are several examples of such networks in this special issue. Kratzer, Lettl, Franke, and Gloor (2015) investigate whether lead users—innovative users of a product or service who have needs that are not included in the product and who would benefit greatly if they obtained a solution to these needs (von Hippel, 1986)—occupy different positions in their social network than do nonlead users. Because lead users not only are innovative, but develop solutions to real needs that other customers of the company (whose products are innovated by the lead user) could benefit from as well, companies are often interested in tracing who their lead users are. Identifying their lead users can be costly and time-consuming, so firms could benefit greatly from being able to recognize their lead users from the position they occupy in easily observable and measurable social networks. Kratzer and his colleagues find that lead users appear to occupy a distinct network position and that certain web mining techniques can be useful in a firm's quest for its lead users.

A slightly different, contemplative, perspective is provided by Iacobucci and Hoeffler (2015) explore how firms can tap into the social networks around them and leverage their ability to develop radically new products. Rather than identifying lead users from the online networks they inhabit, Iacobucci and Hoeffler discuss the option of mining the online conversations that occur among lead users in order to uncover common problems, novel solutions, or analogous challenges. Furthermore, they discuss that the way in which new products and ideas diffuse through the market is not quite understood yet, despite the existence of well-researched and oft-cited models. The reason for the lack of insights these models have generated—they focus specifically on the Bass model (Bass, 1969)—is because they are underdeveloped in terms of the network theory that underlies them. Extending the model with established findings from the social networks literature on how behavior, such as product adoption, is mimicked among customers might further improve the model—this is especially useful in cases when no previous adoption history is available by which to calibrate the "regular" parameters of the Bass model. In addition, the authors argue that firms could gain much additional relevant knowledge and ideas by following, establishing, supporting, and participating in online platforms that stimulate focused networking among dedicated (potential) customers and users.

In their contribution to this special issue, Mukherjee, Uzzi, Jones, and Stringer (2015) employ a network approach to study innovation by individuals, in particular by scientists. Their starting point is that the products that scientists develop are articles in academic journals, in which their created knowledge and ideas are expressed. Mukherjee et al. address two issues: how can one objectively measure how innovative a new product (here: a scientific article) is, and what makes an innovative product successful. Their approach is not to study the network among the innovators (i.e., the scientists) themselves, but to study the network "inside" their products: they argue that new products (such as scientific articles) are made up of combinations of already existing products and technologies (as evident from citations), mixed with a bit of newness. The way in which existing technology is combined in a new product can itself be more or less new: combinations of technologies that have already been combined in many previous products can be characterized as conventional, whereas combining existing technologies that have not been combined much before is a sign of novelty. The authors thus build a network of citations between scientific articles (and the journals these have been published in) and compare the dyads of journals that are jointly referenced by an individual article to the general tendency for this dyad to occur across the population. In line with the product innovation literature (Glynn, Kazanjian, and Drazin, 2010; Griffin, 1997; Griffin and Page, 1996; Van Engelen, Kiewiet, and Terlouw, 2001) and innovation in science (Guimerà, Uzzi, Spiro, and Amaral, 2005; Wuchty, Jones, and Uzzi, 2007), the authors find that teams are better at reaching for novel combinations than are individuals and that the output by teams is more likely to be successful than that by individuals. A startling finding is that their extensive analysis shows that science appears to become increasingly conventional and that drawing on atypical combinations of prior work becomes increasingly rare. Considering that science is an important indicator of the (fundamental) research that is performed in universities and company laboratories, this is an alarming finding that, it is suggested, should be researched in more depth in future research.

Conclusion

Although innovation is a collaborative endeavor, where multiple actors interact and work together to develop something new, there is relatively little research that studies the patterns and structures of collaboration ties with the help of formal theory and methods specifically developed to do this. Social network analysis is a method that explicitly addresses interaction patterns. The eight articles in this special issue (and the references therein) provide readers with an overview of the type of research that can fruitfully be performed when a social network lens is employed. Some of the articles employ specific social network analysis measures, others address the role of social networks more loosely, but each highlights unique aspects of how a social network study of innovation offers novel insights. It is the expectation in this introduction that the reader will enjoy the special issue as much as we have enjoyed bringing the articles together. But above all, many more scholars may find inspiration in the approach and will put on a social network lens as part of their future work on innovation.

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