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The architecture and dynamics of global networks

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Global networks

It has become a stylized fact that patterns of interorganizational connections affect a variety of organizational outcomes. For example, an organization's ability to assemble varied knowledge from diverse sources to serve its strategic goals is a key to productive innovation and an important source of competitive advantage (e.g., Baum, McEvily, & Rowley, 2012; Owen-Smith & Powell, 2004; Powell, 1996). Network structures of interorganizational collaborative relationships can either enable or constrain an organization's ability to achieve this outcome by shaping its access to the flows of tacit knowledge, information, and other resources.

Many earlier treatments of interorganizational networks relied on the *ego-network perspective* to explain organizational outcomes. In this view, a firm's ties to its partners and the partners' ties to each other were deemed critical in shaping an organization's access to external resources (e.g., Ahuja, 2000a; Zaheer & Bell, 2005). In contrast, more recent work has accentuated the importance of *a global-network perspective*—the approach that emphasizes the importance of the overall structure of firms and their ties within an industry or an organizational field to explain a variety of organizational outcomes (Rosenkopf & Schilling, 2007; Schilling & Phelps, 2007; Tatarynowicz, Sytch, & Gulati, 2016). Put differently, one can think of global networks as the wider swaths of a social system, which are constituted by the interconnected ego-networks of individual organizations (see Figure 21.1).

A growing body of research shows that understanding the architecture and dynamics of global interorganizational networks can advance our understanding of how the social structures of markets shape organizational and collective outcomes (Schilling & Phelps, 2007; Sytch & Tatarynowicz, 2014;

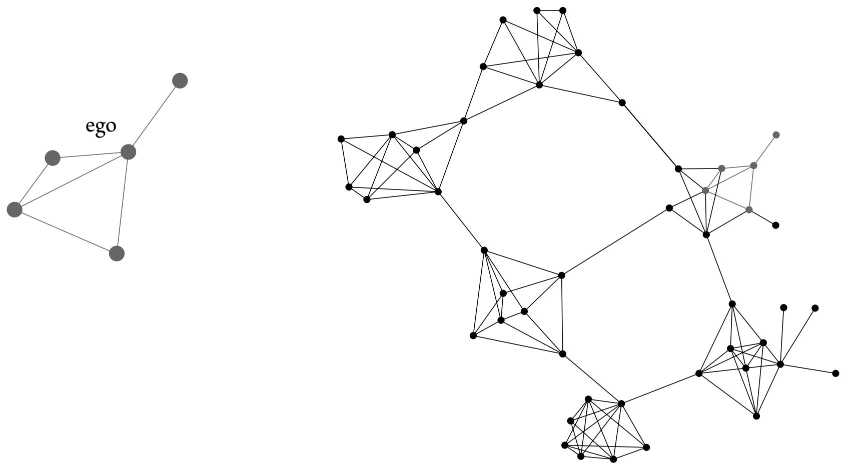

Figure 21.1 (A) Ego-network perspective; (B) Global-network perspective

Tatarynowicz et al., 2016). Below, I explicate some of the central findings and the future promise of this research.

Architecture global networks

One of the key reasons for studying global networks stems from the fact that global network properties critically affect the knowledge, information, and other resources that are available to actors locally through their direct connections. To illustrate, consider a firm whose ego-network structure remains unchanged, whereas the global network of relationships in which the ego-network is situated is changing, thereby affecting the local availability of resources. Alternatively, the cross-sectional variation in global network properties across industries and organizational fields can affect the outcomes of firms with otherwise similar ego-networks.

One specific architectural configuration that describes a wide range of interorganizational networks is that of a small world. Following an early thought exercise by Hungarian writer Frigyes Karinthy (1929), an ingenious experiment by Stanley Milgram (1967),[1] and seminal work in mathematical sociology (White, 1970), the small-world property received a rigorous mathematical formulation in the work of Watts and Strogatz (1998). Watts and Strogatz (1998) described small-world networks as those that combine high levels of clustering with low average path-length. This indicates a structure in which dense pockets of connectivity are interconnected sparsely by bridging ties. Figure 20.1B illustrates a typical small-world network. Small-world network properties have been found to describe interorganizational networks of board interlocks (Davis, Yoo, & Baker, 2003), corporate ownership (Kogut & Walker, 2001), investment syndicates (Baum, Shipilov, & Rowley, 2003), and interorganizational partnerships (Gulati, Sytch, & Tatarynowicz, 2012), among others.

Significantly, the small-world properties of interorganizational networks were also found to affect organizational outcomes. For example, in a longitudinal study of alliance networks across 11 different industries, Schilling and Phelps (2007) found that firms embedded in small-world networks enjoyed greater invention productivity as measured by annual patent applications. The central argument of Schilling and Phelps' (2007) suggests that high clustering allows the system to retain locally homogeneous pockets of knowledge and information that are also sufficiently distinct from one another. Low average path-length, in turn, enables this knowledge to be transferred to some degree across different pockets, thereby ensuring requisite knowledge variety for recombinant innovation. Schilling and Phelps' (2007) work built on earlier influential work by Uzzi and Spiro (2005), who found that the small-world properties of the social structure of Broadway artists led to the financial and artistic success of the musicals.

Complementing this line of work, some studies are concerned with the implications of global network architectures for collective outcomes, such as the degree to which administrative practices, governance norms, or knowledge are diffused through organizational fields or industries (e.g., Abrahamson & Rosenkopf, 1997). For example, Tatarynowicz et al. (2016), proposed a typology of global network systems that includes clan, community, and convention network architectures. Two central properties of networks constitute the cornerstone of this typology: (1) the strength of a global network's community structure; and (2) its degree of connectedness.[2] Clan structures are characterized by high levels of community structure, but low connectedness, resembling densely clustered but often fragmented network structures. Such networks were found to describe the partnership networks in the automotive, new materials, and chemical industries. Community structures, in turn, feature high network connectedness and medium community structures, describing partnership networks in biotechnology and pharmaceuticals, micro-electronics, and telecommunications. Convention networks were distinguished by high connectedness and weak community structures and were not found in any of the studied industries (Tatarynowicz et al., 2016). The results of computational models simulating knowledge diffusion indicated that community networks significantly outperform both clan and convention networks, whereas clan networks fare noticeably better compared to convention networks. It is essential to note that the explanatory power of the clan–community–convention typology was significantly stronger when compared to that offered by a range of alternative global network properties, including the small-world quotient.

Scholarly focus on collective outcomes has led some researchers to study the robustness of global network structures, conceptualized as their ability to withstand the removal of nodes or ties (Albert, Jeong, & Barabási, 2000). For example, Chu and Davis (2016) documented the collapse of the American corporate interlock network in the 21st century, which severely constrained the rapid diffusion of information and corporate practices among organizations. In a parallel seminal argument, Mizruchi (2013) illuminated the fracturing of the American corporate elite, which started in the 1980s and which severely limited its capacity for collective action.

Dynamics of global networks

To gain a deep understanding of how networks affect organizational and collective outcomes, it is imperative to examine how and why they evolve to obtain the observed structural configurations. Some scholars contend that scholarly understanding of network outcomes is "incomplete and potentially flawed without an appreciation of the genesis and evolution of the underlying network structures" (Ahuja, Soda, & Zaheer, 2012: 434). Studies of global network dynamics, consequently, are concerned with the origins and types of change in global network properties.

In one approach to studying the dynamics of global networks, scholars have examined the role significant industry events play in the evolution of global network structures. In the context of a partnership network of a global steel industry, Madhavan et al. (1998) explored how major technological and regulatory events can either reinforce or loosen the network's existing structural properties, as measured by the overall centralization of the global network. More principally, this research echoes the fundamental insight that interorganizational relations can co-evolve with the technological landscape of the industry (Glasmeier, 1991; Rosenkopf & Tushman, 1998). This work uncovers, for example, that the evolving structure of interorganizational relationships can play a potent role in industrial environments characterized by high levels of uncertainty by helping adjudicate among competing technological alternatives. The selection of a dominant design in an industry, in turn, can noticeably stabilize and constrain the evolution of the network (Rosenkopf & Tushman, 1994).

In another approach to studying network dynamics, inspired by the central property of complex social systems, scholars trace the emergence of distinct global forms to actor-level collaborative behaviors (Coleman, 1990). For example, Baum et al. (2003) linked the emergence of a small-world system to the formation of bridging relationships by peripheral firms, a behavior that subsequently resulted in the firms being positioned on the intersection of network pathways connecting other firms. In a study of the dynamics of network of partnerships in the global computer industry, Gulati, Sytch, and Tatarynowicz (2012) found that the pursuit of bridging relationships by firms searching for heterogeneous knowledge inputs engenders a small-world system, while also planting the seeds of its subsequent demise. Specifically, the excessive formation of bridging relationships by firms in the pursuit of diverse knowledge resulted in the increased connectivity among network communities, which reduced the very diversity these bridging ties were designed to harness. This dynamic subsequently led to a decline in the formation of bridging ties and a drop in the average path-length of the system, thereby resulting in the erosion of the small-world architecture.

Taking a contingency view, some work aims to investigate how variations in the properties of an industrial context can trigger different types of firms' collaborative behaviors, thereby giving rise to different architectural properties of global networks. Clan networks, for example, are more likely to be found in technologically less dynamic industries, in which firms may favor the preservation of existing resources over access to novelty. This is a strategic imperative that is best supported by the formation of closed ego-network structures. In contrast, community networks tend to describe more technologically dynamic industries where access to novelty—best enabled by the formation of open ego-networks—could be an essential imperative for a firm's success and survival (Tatarynowicz et al., 2016).[3]

Dynamics of network communities

Investigating global network architectures opens considerable opportunities for studying network communities, or meso-level structures, that lie between ego-level and global-level networks. Indeed, one of the most established paradigms in the study of social structures (Burt, 1992) posits that actors' access to diverse knowledge stems from connecting with alters that are not directly interconnected. Research suggests that many interorganizational networks feature network communities; that is, structural groups within the network, in which firms are connected more to one another than to firms outside the group (Rosenkopf & Schilling, 2007). Figure 21.2 illustrates the network-community perspective in the analysis of social structures. An important

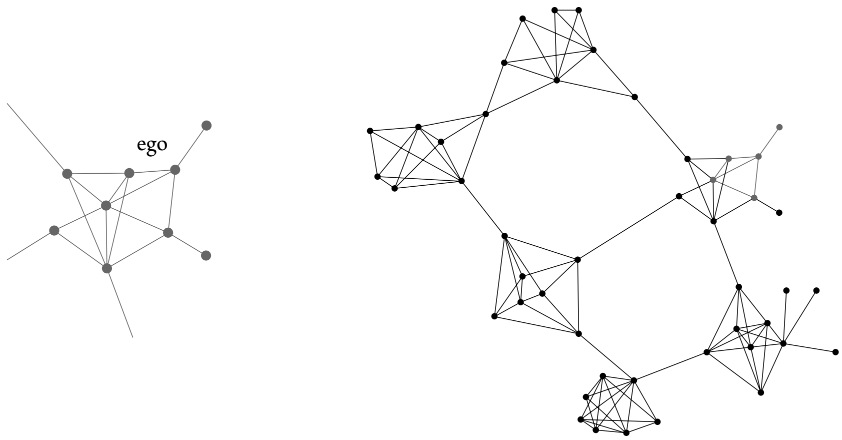

Figure 21.2 (A) Network-community perspective; (B) Global-network perspective

aspect to consider is that within these structures, diverse knowledge comes not from connecting to actors that are directly unconnected (many of which can be found inside network communities), but rather from connecting with actors that reside in different network communities.

Furthermore, the focus on network communities offers exciting opportunities for studying how membership dynamics can affect the distribution of and actors' access to diverse knowledge. In simplest terms, imagine two networks that retain similar patterns of connectivity over time. One is characterized by some degree of churn among its members, whereas the other is not. Focusing on the dynamics of network communities allows scholars to systematically investigate the implications of firms' movement across network communities.

Intuitively, we could suspect that these differences could matter for access to new knowledge and resources. Using social-network analytic techniques for community detection in networks, which use comparable random networks of the same size and connectivity as a baseline, studies have found that numerous interorganizational networks have robust community structures. These range, for example, from networks of interorganizational partnerships in computers and microelectronics (Sytch & Tatarynowicz, 2014; Tatarynowicz et al., 2016) to networks of co-participation in investment syndicates in financial services (Shipilov, Li, & Greve, 2011).

The assumption underlying the importance of attending to a network's community structure is that resources, knowledge, and information *across* network communities are more heterogeneous than *within* network communities. Some empirical tests have been conducted of this baseline assumption. For example, Sytch and Tatarynowicz (2014: 261–262) found that not only do firms select into network communities based on similar knowledge endowments, but also that their endowments become more similar to those of other community members after these firms become members of the same community. As a result, when comparing firms on observable knowledge attributes (e.g., patent stocks) within and across network communities, firms that belong to the same network community are substantially more similar to one another in the aggregate than one would expect based on random chance. This finding, in turn, suggests that a firm's membership in a network community can constrain its ability to access diverse knowledge and innovate. Furthermore, it can result in patterns of dependence on those partners that offer access to diverse knowledge. This finding also points to opportunities for building a power advantage and facilitating creative outcomes when drawing on the varied knowledge that different network communities offer.

Considering this, *membership dynamics* in network communities can help firms avoid staying locked into a homogenous knowledge base of a given network community. In dynamic interorganizational systems, frequent entries and exits of firms, as well as pronounced changes in the patterns of interorganizational tie formation can drive changes in the membership of network communities over time. Importantly, studies have shown that the dynamics of network community membership can enable firms to access new knowledge. More specifically, firms can benefit from the membership dynamics of network communities either indirectly or directly. The indirect effect results from the turnover of community members, which exposes incumbents to new knowledge and resources that are brought in by new community members. The direct effect, in turn, arises when a firm moves across different network communities over time and gains direct exposure to the distinct knowledge bases of those communities. Both of these dynamics have been shown to enhance firms' patenting rates in a complex, nonlinear fashion (Sytch & Tatarynowicz, 2014).

Future research

The exceptional promise of future research on the architecture and dynamics of global networks stems from recognizing that the explanatory power of socio-structural models can be enhanced if we begin to assess how social structures shape *access* to resources and their *availability* to corporate actors. Earlier work on the effects of ego-networks has illuminated how companies can access resources offered by the social structures of markets (e.g., Ahuja, 2000a; Burt, 1992; Powell, Koput, & Smith-Doerr, 1996). However, this work has offered comparatively less insight into the availability and the distribution of resources within a given social system or across social systems. Yet it is the architecture and the dynamics of global and meso-level network properties that can help illuminate the heterogeneity in resource distributions with a given network system and across different network systems. Viewing networks as nested, multilevel structures is therefore important, because differences in private advantage are likely to be driven by variations in the extent to which companies can tap into local resources through their ego-networks and by the quality of the local resources enabled by the global- and meso-level network properties and dynamics.

For example, consider that two computer companies with identical ego-network structures can reap different levels of invention productivity depending on membership turnover and dynamics in their network community. In addition, one of the firms might move across different network communities frequently, whereas the other might remain in the same community over time. Again, these varying dynamics will translate into differences in the firms' invention levels (Sytch & Tatarynowicz, 2014). By the same token, if we compare a telecom and an automotive company with the exact same ego-network structure, the telecom company is likely to have access to broader and more diverse resources. This is because the community network that binds telecom companies enables knowledge flows across the industry much more effectively than the fragmented clan network interlinking automotive companies (Tatarynowicz et al., 2016).

Furthermore, a holistic, multilevel analysis of nested social structures could help us resolve inconsistencies in some of the empirical results surrounding models of private advantage (Ahuja, 2000a; Burt, 1992). For example, comparing the effects of brokerage across different empirical contexts may be futile until we understand the global network properties and the community structures in both contexts. Doing so would elucidate the degree to which heterogeneous knowledge is available in the system in the first place; and whether, for example, the brokered contacts reside in the same or different network communities.

In addition to providing greater explanatory power and precision to models of private advantage, understanding the dynamics of global network structures can help better discern variations in collective outcomes such as knowledge diffusion. Consider, for example, the degree of connectedness of a network system, which can be captured as the proportion of actors belonging to the giant component of the network or the distribution of network components by size. Network connectedness denotes one the most basic properties of the global network architecture, which is essential for supporting knowledge diffusion through the system.

Yet, even if the network system does not have high levels of connectedness, it may still be very effective for diffusion because it may possess a sufficient number of transient connections that are present during a particular time period but dissipate quickly. In fact, depending on where, exactly, in the global network architecture these connections emerge, networks with lower levels of connectedness could conceivably outperform those with higher levels of connectedness in longer, multiperiod diffusion processes (Tatarynowicz et al., 2016). Commitment to studying global network dynamics, therefore, could lead scholars to reconceptualize certain well-established network properties as dynamic facets of social systems, leading to a deeper understanding of how they can shape collective outcomes.

NOTES

1 This classic experiment by Stanley Milgram (1967) conflated the investigation of the structural properties of networks with the actors' ability to search through networks. See Singh et al. (2010) for a revised and improved experimental design.

2 Network connectedness reflects the extent to which actors in the network can reach one another via an existing network path of some length. Community structure, in turn, captures the distribution (rather than existence) of network ties throughout the network: strong community structure signals the presence of many smaller subgroups (or communities) of densely interconnected firms.

3 A closed firm's (ego-) network is described by the firm's connections to partners that are themselves interconnected; in contrast, an open ego-network features a firm's connections to partners that are not directly connected to one another. For a detailed treatment of the benefits and costs of the two ego-network positions, see Burt (1992).