10.5465/AMBPP.2019.235

LOCI OF DYNAMICS IN FIELD NETWORKS AND THEIR IMPACT ON INNOVATION OUTCOMES: R&D CONSORTIA IN THE DUTCH WATER SECTOR

REMCO S. MANNAK
Department of Organization Studies
Tilburg University
Warandelaan 2, 5000 LE, Tilburg, The Netherlands

ARJAN MARKUS
Tilburg University

MARIUS T.H. MEEUS
Tilburg University

JÖRG RAAB
Tilburg University

ALEXANDER C. SMIT
VU Amsterdam

INTRODUCTION

In their pursuit of innovation, firms often join research and development (R&D) consortia, i.e. social entities that enable firms to pool their resources and skills with other organizations. Consortia foster organizing capacity to address complex problems and to shorten time to market trajectories in rapidly changing environments (Doz, Olk, & Ring, 2000; Powell, Koput, & Smith-Doerr, 1996; van Rijnsoever, van den Berg, Koch, & Hekkert, 2014). However, the pursuit of innovation continues beyond the consortium boundaries, because diverse and non-redundant information resides between these social clusters rather than within the clusters (Burt, 2005; Schilling & Phelps, 2007; Ter Wal, Alexy, Block, & Sandner, 2016; Whittington, Owen-smith, & Powell, 2009). Access to these diverse knowledge pools is contingent on the sector-wide network structure resulting from organizations' simultaneous participation in multiple consortia. The study especially investigates the role of two network features, *clusters* and *connectors*. We define organizations participating in only one consortium at a time as clustered actors. In addition, we distinguish connectors or "hubs": organizations participating in multiple consortia simultaneously and creating connections between different consortia. Connectors are thus located on the shortest path between any pair of other actors in the network. A network structure that exhibits a combination of clusters and connectors between these clusters benefits innovation at the individual, organizational, consortium, and national level, because such a structure provides both organizing capacity and knowledge access (Chen & Guan, 2010; Fleming, King III, & Juda, 2007; Schilling & Phelps, 2007; van Rijnsoever et al., 2014). The question is, however, to what extent these clustering and connector benefits are sensitive to *network dynamics*, as recently advocated by multiple scholars (Ahuja, Soda, & Zaheer, 2012; Tatarynowicz, Sytch, & Gulati, 2015).

Network structure is inherently dynamic due to membership turnover over time and such dynamics are likely to impact innovation (Powell, White, Koput, & Owen-Smith, 2005; Sytch &

10.5465/AMBPP.2019.235

Tatarynowicz, 2014). While network stability facilitates the development of mutual understanding and network routines (Dyer & Singh, 1998; Zhang, Duan, & Zhou, 2017), network dynamics mitigate homogenizing tendencies and enhance novelty value through the influx of new partners (Kumar & Zaheer, 2018; Vissa & Bhagavatula, 2008). However, due to the potentially disruptive effect of partner turnover on routine development (Zhang et al., 2017), network dynamics might also frustrate the generation of innovation. In this paper, we aim to contribute to the existing literature on network structure and dynamics by studying distinct network areas, or loci, of network stability and dynamics. We explore how configurations of network dynamics and structure may matter for our understanding of how networks influence the generation of innovation. For instance, networks with stable clusters and dynamic connectors might both benefit from *routine* organizing capacity and from *novel* access to diverse knowledge pools. Hence, we respond to the following research question: *To what extent do distinct loci of network dynamics influence the innovation outcomes of research and development (R&D) consortia embedded in these networks?*

THEORETICAL BACKGROUND

In this section, we first introduce our conceptualization of clusters and connectors (network structure), followed by network stability and dynamics, and we conclude with our hypothesis. Prior research has argued that organizations in clustered loci in the network are likely to share the same norms and values, while deviating behavior is likely to be sanctioned by the members of the clustered part of the network (Coleman, 1988; Uzzi & Spiro, 2005). In addition, clustering facilitates the transfer of knowledge and information among these clustered organizations (Schilling & Phelps, 2007). When organizations require additional support to understand and absorb that knowledge, tightly interlinked partners are likely to support each other, for instance via joint problem-solving (Uzzi, 1997; Zaheer & Bell, 2005). Thus, clustering facilitates *organizing capacity* of network members.

Clustering is complemented by connections or shortcuts between these clusters (Rosenkopf & Padula, 2008; Schilling & Phelps, 2007). Building on the notion that knowledge within clusters is more homogeneous than between clusters, relationships that connect such clusters are crucial for the movement of diverse and novel knowledge in the network. Accordingly, connectors offer *access to diverse knowledge pools*.

The structural view on networks has been used extensively although recently several criticisms surfaced with regard to the dominant static perspective and the role of agency (Ahuja et al., 2012; Sytch, Tatarynowicz, & Gulati, 2012). Networks are dynamic social systems in which membership and network structure change over time (Berends, van Burg, & van Raaij, 2011; Gay & Dousset, 2005; Gilsing, Cloodt, & Roijakkers, 2016). This in turn may impact the level of social capital of organizations in the network (Burt & Merluzzi, 2016; Kumar & Zaheer, 2018). We zoom in on an important dimension of network dynamics by examining the impact of entry, persistence, and exit of members (or nodes) in networks, the most prevalent network dynamic in our research context. With increasing duration of network membership, the network increases its stability (i.e. low dynamics).

Network stability refers to the situation in which the network experiences little entry and exit of organizations and thus most nodes remain in the network (Ahuja et al., 2012). A stable set of collaborative partners could improve the knowledge transmission efficiency as sender and receiver accumulate shared routines, beliefs and cognitive templates, which in turn can facilitate

10.5465/AMBPP.2019.235

communication, mitigate conflict and build-up trust (Dyer & Singh, 1998; Tortoriello & Krackhardt, 2010). Therefore, stability facilitates the development of *network routines*.

At the same time, turnover of nodes mitigates the homogenizing tendencies or lock-in that networks commonly experience (Ahuja et al., 2012; Gulati & Westphal, 1999; Sytch & Tatarynowicz, 2014). Arrival of new members reduces conformity pressures and allow incumbent network members to observe and learn from those new partners as they bring novel knowledge, skills and resources (Kumar & Zaheer, 2018; Vissa & Bhagavatula, 2008). Accordingly, network dynamics may offer *novelty value* to incumbent network partners.

Hypothesis

Our theoretical arguments clarify how stability and dynamics occurring in clustered and connector loci of the network foster the generation of innovation among R&D consortium members. First, rigid networks are characterized by both stable clusters and stable connectors due to prolonged network membership and low inflow of novel organizations. In such networks, *routine knowledge access* (stable connectors) is combined with *routine organizing capacity* (stable clusters). However, due to a lack of new entrants, R&D consortia in these networks will start to suffer from a lack of novelty of knowledge and become over-embedded and inert (Ahuja et al., 2012; Kumar & Zaheer, 2018), resulting in low innovation potential.

Second, volatile networks are expected to provide *novel access to diverse knowledge pools* (dynamic connectors) combined with *novel organizing capacity* (dynamic clusters). Due to a lack of meaningful integration and trust building, the continuous entrance and exit of new nodes ultimately affects innovation outcomes negatively.

Combining the benefits from both network stability and dynamics has led prior research to assert that moderate turnover of network members generally favors the innovation capacity of the network (e.g. Sytch & Tatarynowicz, 2014). However, developing routines in clusters that simultaneously experience inflow of new entrants is very difficult due to the disruption of learning processes, confidentiality issues, and non-disclosure agreements. Hence, this study builds on the existing literature on network structure and dynamics to argue that R&D consortia embedded in these networks are most likely to achieve innovation outcomes, when network stability occurs in clustered loci of the network, while network dynamics occurs in connector loci of the network, or vice versa.

Third, a dynamic connector-stable cluster network offers the benefits of *routine organizing capacity* to members of the network, because over time, repetitive interaction allows clustered organizations to better understand each other, improving the communication and trust among the participants (Narayan & Kadiyali, 2016). In addition, the connector dynamics allow for *novel knowledge* to seep into the clusters, as well as best practices, the latest trends and developments from various domains (Kumar & Zaheer, 2018; Sytch & Tatarynowicz, 2014). We therefore predict that the dynamic connector-stable cluster network configuration benefits the innovation outcomes of R&D consortia.

Fourth, the stable connector-dynamic cluster configuration promotes innovation outcomes, because the connectors gather a wide set of collaborative routines and absorptive capacity by collaborating with a diverse set of organizations over time. Connectors accumulate relational experience which in turn amasses a network memory (Soda, Usai, & Zaheer, 2004). The stable connectors can access, distribute and recombine the diverse knowledge originating from the varying sets of clusters. This particular network configuration combines *routine access*

10.5465/AMBPP.2019.235

to diverse knowledge pools with *novel organizing capacity* to effectively recombine knowledge into innovation. In sum, we hypothesize that:

> *Hypothesis 1. The probability of innovation outcomes for R&D consortia is higher in networks with dynamic connectors combined with stable clusters and in networks with stable connectors combined with dynamic clusters rather than in rigid or volatile networks.*

METHOD AND RESULTS

Our analyses attempt to demonstrate the extent to which network dynamics, in terms of average connector stability and cluster stability, influence the innovation outcomes of consortia in the network. The consortium is the unit of analysis, with connector and cluster stability measured at the network level. We explore the network dynamics of 318 consortium members of 104 R&D consortia in the Dutch water sector over 23 years (1982-2004). The network has evolved over 23 years through membership turnover, which is the result of entry, exit, and organizations repeating their collaboration in multiple consortia over multiple years. Interorganizational relations are counted if and only if they are part of a joint consortium in a given year. The average consortium duration was 4 to 5 years. We acquired unique secondary data from annual reports published by a Dutch technology program that facilitates demand-driven university-industry collaboration in the Netherlands.

Innovation outcomes, the dependent variable in this study, are a feature of *consortia*, pertaining to the extent to which consortia in the network achieve socially, technologically, and economically viable innovation outcomes (e.g., wave modeling, wastewater treatment technology). The value for innovation outcomes for R&D consortia is derived from the evaluation reports of the Dutch technology program that funds the R&D consortia in our research population. This agency appointed an external committee of specialists from industry and academia to rate the innovation results of the funded consortia at 5 and 10 years after their launch.

Connector stability and cluster stability are measured at the network level (at t_0), with reference to the average proportion of prior years in which current connectors (connector stability) and current actors in clusters (cluster stability) have participated in the network. In other words, the connector stability of the network increases with the length of time that connectors (actors on the shortest path between any pair of other actors) have participated in the network. To address endogeneity concerns regarding the network dynamics, we apply a two-stage instrumental variable (IV) probit model.

The results support Hypothesis 1 that R&D consortia in networks in which either connectors are stable while cluster are dynamic, or clusters are stable while connector are dynamic (the ‘dynamic connector-stable cluster’ configuration and in networks with the ‘stable connector-dynamic cluster’ configuration), have a significantly higher probability of innovation outcomes than do networks with low, moderate, or high levels of both connector and cluster stability. Given the limited sample size, we also ran a bootstrapped model with 1000 replications, which provides identical results. Furthermore, we computed the average marginal effects of connector and cluster stability and conducted Bonferroni adjusted post hoc tests. These tests confirm that the probability of innovation outcomes is lowest (close to 0%) in networks that either combine low (0.125) levels of connector stability with low (0.125) levels of cluster

10.5465/AMBPP.2019.235

stability (volatile network) or that combine high (0.750) levels of connector stability with high (0.500) levels of cluster stability (rigid network). The probability of innovation outcomes is highest (close to 100%) in networks that either combine low (0.125) levels of connector stability with high (0.500) levels of cluster stability (dynamic connector – stable cluster network) or that combine high (0.750) levels of connector stability with low (0.125) levels of cluster stability (stable connector – dynamic cluster network). In networks with moderate levels of cluster and connector stability the probability of innovation outcomes is approximately 54%.

DISCUSSION

We began by noting that network structure and dynamics might interactively influence the innovation outcomes of R&D consortia in the Dutch water sector. Building on network theoretical arguments we developed and tested a configurational taxonomy of network dynamics in different network loci to conceptualize the interplay between network structure and dynamics. We explore how clusters in networks and connectors between these clusters can range from stable to dynamic, resulting in four distinct configurations of network dynamics.

The key contribution of our study is to extend network theory by bridging research on network structure and dynamics. By demonstrating that neither *rigid* nor *volatile* industry-wide networks foster innovation, our findings endorse the important call for studying network dynamics in more detail (Ahuja et al., 2012; Powell et al., 2005; Tatarynowicz et al., 2015; Zhang & Guler, 2019). Indeed, membership turnover in networks "can provide critical access to heterogeneous knowledge and resources" (Sytch & Tatarynowicz, 2014: 274). At the same time, our findings refine prior insights, because we show that it is not just 'moderate dynamics' that facilitate superior innovation outcomes, but it is the locus of network dynamics that matters. Our results reveal that the probability of innovation outcomes of R&D consortia is highest in networks with either *cluster* stability (stable memberships of organizations in clusters) or *connector* stability (stable memberships of connectors between clusters), combined with dynamics due to membership turnover in the respective other part of the network. As long as one network locus is stable and another locus is dynamic, consortia embedded in the network experience an above average likelihood of innovation outcomes. Other combinations of stability and dynamics in distinct network loci produce significantly lower probabilities of innovation outcomes.

Our findings revisit existing network theoretical arguments for innovation outcomes. Extant literature on ego-network dynamics (Baum, McEvily, & Rowley, 2012; Soda et al., 2004) has argued that clusters should mature over time to develop *routine organizing capacity,* because it takes time to develop joint norms, trust, and mutual understanding, while *access to diverse knowledge pools* should be *novel*, since non-redundant information gets outdated quickly. Our findings on the 'dynamic connector-stable cluster' configuration endorse these claims. However, the 'stable connector-dynamic cluster' configuration seemingly challenges existing network theoretical arguments. Our findings point to the idea that stable connectors can develop *network routines* for attracting new entrants (Gay and Dousset, 2005; Powell et al., 2005, 1996), while providing *access to diverse knowledge pools*. Hence, the connector itself does not have to be novel in order to transmit novel information, provided it has access to dynamic clusters. In addition, our findings reveal that clusters do not necessarily require long-term experience to provide organizing capacity.

10.5465/AMBPP.2019.235

Our study offers new insights into traditional arguments regarding network structure and dynamics. While extant literature on interorganizational networks underlines both network dynamics and structure, few attempts have been made to understand how these network features simultaneously influence organizations' ability to generate innovations. This research seeks to address this chasm in the context of a policy initiative in the Dutch water sector. The findings in our study point to a tradeoff between network dynamics and stability, as well as network clusters and connectors. The study offers a valuable and comprehensive framework on the basis of which future research can continue to explore how network dynamics and structure interplay in a variety of contexts. This should lead to a better understanding of how networks change over time and how dynamics co-evolve with innovation capacity of R&D consortia and organizations active in the network as well as the networks as a whole. With the present article, we therefore aim to encourage research scholars toward further investigating network structure, its dynamics and the impact on innovation.

REFERENCES AVAILABLE FROM THE AUTHORS