



What makes you more central? Antecedents of changes in betweenness-centrality in technology-based alliance networks[☆]



Victor A. Gilsing^{a,*}, Myriam Cloudt^b, Danielle Bertrand-Cloudt^c

^a ACED, Department of Management, Faculty of Applied Economics, University of Antwerp, Prinsstraat 13, 2000 Antwerp, Belgium

^b Department of Innovation, Technology Entrepreneurship and Marketing, School of Industrial Engineering and Innovation Sciences, Eindhoven University of Technology, P.O. Box 513, 5600 MB Eindhoven, The Netherlands

^c ROA & NSI, School of Business and Economics, Maastricht University, P.O. Box 616, 6200 MD Maastricht, The Netherlands

ARTICLE INFO

Article history:

Received 29 September 2015

Received in revised form 13 June 2016

Accepted 2 July 2016

Available online 11 August 2016

Keywords:

Centrality
Interfirm networks
Network positions
Pioneering technology
Alliance portfolios
Network agency

ABSTRACT

Although central network positions have been associated with above average performance effects, an important void that still remains is how firms come to occupy a more central position in the first place. Whereas recently made exogenous explanations have shed some more light on aggregate changes in centrality, they remain silent on an endogenous understanding of how individual firms come to occupy a more central position. To address this, we argue and demonstrate how heterogeneity in firm-level attributes formed by their possession of pioneering technology, alliance portfolio size and choice for alliance organization drives differences among firms in becoming more central. Based on a sample of technology-based alliances in two different high-tech industries (pharmaceuticals and the broader ICT industry), we find evidence for all our four hypotheses. We contribute to the literature by considering changes in position as a dependent variable, which goes beyond the dominant approach in which network structural properties have mostly been treated as independent variables. In this way, we contribute to an emerging literature in which the focus shifts away from how network embeddedness enables and constrains action towards what factors affect and shape a firm's network embeddedness through the lens of its structural position.

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1. Introduction

A growing number of studies have shown that strategic alliances and interfirm networks are particularly relevant for innovation and the development of new technology (Debackere et al., 1996; Ahuja, 2000a; Gilsing et al., 2008; Phelps, 2010; Sampson, 2007; Ozcan and Islam, 2014; Arroyabe et al., 2015). Especially in technology-based industries, alliances can be considered as conduits through which firms can get access to the complementary resources and knowledge of partners (Gimeno, 2004; Powell et al., 1996). Moreover, it has been argued that a firm's position in an alliance network affects the speed and degree in which access to these external resources can be acquired. More specifically, it has been demonstrated that a central position provides a firm with faster access to high(er) quality external resources and capabilities than a less central one (Powell et al., 1996; Zaheer and Bell, 2005). In line with this, a central position has been demonstrated to carry positive effects on, among others, power (Krackhardt, 1990),

reputation (Galaskiewicz, 1979; Stuart, 1998), early adoption of innovations (Rogers, 1971), innovation performance (Powell et al., 1996) and learning (Hamel, 1991).

Even though there is a large heterogeneity among firms in network positions (Provan and Sebastian, 1998), a firm's network position is not fixed and may change over time. Here, changes in technology and/or regulation have been advanced as exogenous explanations of changes in positions of individuals in intra-firm networks (Burkhardt and Brass, 1990) as well as of changes in firms' positions in alliance networks (Madhavan et al., 1998). This still leaves open an endogenous understanding of changes in centrality, and in line with this how firms can possibly come to occupy a more central position. Most studies on interfirm networks until now have examined a firm's centrality (Powell et al., 1996), their number of alliances (Shan et al., 1994) or their number of direct and indirect partners (Ahuja, 2000a) within the context of their local network structure. However, firms' local network structures are embedded in a global network structure or 'large-scale network', which has hardly been considered until now (see Schilling and Phelps, 2007 for an exception). This is surprising as a global network structure has a deep influence on both the creativity and performance of its members, as shown by for example in a study on artists in Broadway musicals from 1945 to 1989 (Uzzi and Spiro, 2005). To address this void in the literature, this study will focus on a

[☆] This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

* Corresponding author.

E-mail addresses: victor.gilsing@uantwerpen.be (V.A. Gilsing), m.m.a.h.cloudt@tue.nl (M. Cloudt), d.cloudt@alumni.maastrichtuniversity.nl (D. Bertrand-Cloudt).

global network structure and a firm's centrality within it. In line with this, we will focus on betweenness centrality (BC) as this offers a focal firm with strategic benefits in a global network structure such as opportunities for brokerage, faster access to novel information as well as providing it with power in controlling information and resource flows throughout the network (Burt, 1992).¹

To develop an understanding of what makes firms more central, the central thesis of this paper is that heterogeneity in firm-level attributes drives changes in betweenness centrality. Following Burt (1991) who suggests that the causal force behind centrality lies in the direct and indirect 'demand' by alters for relations with a focal actor, we argue that a firm's possession of *resources* makes others desirous of collaboration. We differentiate between both technological resources and social resources, each of potential value to other firms and, in this way, each forming a different antecedent of how a firm may become more central. Technological resources may be of value to others to the extent that they lack this, and may form a major reason why others are interested in collaboration with a focal firm (Ahuja, 2000b; Pfeffer and Nowak, 1976). Here, we specifically focus on the role of pioneering technology (Ahuja and Lampert, 2001). The role of social resources emerges from the social exchange and embeddedness literature, which propose that alliance activity is embedded in a wider network structure from prior and ongoing collaborative relationships (Gulati and Gargiulo, 1999; Walker et al., 1997). To consider this role, we focus on a firm's portfolio of direct partners as this may provide it with access to external knowledge and expertise, as held by its direct partners.

Both technological and social resources emphasize the facilitative role of collaboration and point especially to its benefits but ignore that there may also be risks associated with collaboration. To include such a governance perspective, we also consider the role of alliance organization (choice between equity or non-equity) as a key governance decision to reduce collaborative risks.

Whereas the antecedents of tie formation at the dyad level have been well studied in the literature (e.g. Ahuja, 2000b), the dominant focus until now has been on how network structural properties can be used to advantage (Baum et al., 2000; Burt, 1992; Coleman, 1988; Dacin et al., 1999; Powell et al., 1996; Uzzi, 1996, 1997; Grewal et al., 2006; Phelps, 2010; Phelps et al., 2012; Paquin and Howard-Grenville, 2013; Oliver, 2001; Kijkuit and van den Ende, 2010; Arroyabe et al., 2015). Our study addresses an important void in the literature given this general negligence of the antecedents of network structural properties (Raab and Kenis, 2009; Salancik, 1995). An inquiry into the antecedents of changes in centrality may help to inform us in how far and in what ways firms can come to occupy a more central position. An implication that follows is that we consider changes in centrality as a dependent variable, which serves as an important contribution to the standing literature in which network structural properties have mostly been treated as independent variables. In this way, we also contribute to an emerging literature in which the focus shifts away from how networks enable and constrain action towards what factors affect and shape networks and their structural properties (Ahuja et al., 2012; Gilsing and Nooteboom, 2006; Koka et al., 2006; Madhavan et al., 1998; Rosenkopf and Schilling, 2007; Stolwijk et al., 2013). Overall, our study contributes to an understanding of what makes firms more central in technology-based alliance networks. This serves as an important complement to exogenous explanations that have been advanced until now, such as changes in technology and regulation (Madhavan et al., 1998) or changes in environmental conditions (Koka et al., 2006). Whereas such exogenous explanations can predict aggregate changes

in network centrality, they remain silent on an endogenous understanding of how individual firms can come to occupy a more central position. Our study shows *how* they can. In this way, we also contribute to an emerging debate in the literature regarding the role of agency in networks. Network research has been criticized for failing to show how actors' intentional action may contribute to the creation of network structures that constrain them at the same time (Emirbayer and Goodwin, 1994; Kilduff and Brass, 2010; Salancik, 1995; Toms and Filatotchev, 2004). By considering how heterogeneity in firm-level attributes (formed by their technological and social resources, and their alliance organization) drives differences in increasing their BC, we shed more light on this purposeful, agentic behavior.

Our empirical setting is formed by two global high-tech industries: pharmaceuticals and the broader ICT industry (computers, semi-conductors and telecom). In both industries, interfirm collaboration is a strategic necessity and has led to the formation of so-called 'global' network structures (Schilling, 2009). Our understanding of a global network structure is as follows. Its building blocks are formed by individual dyadic alliances between firms, which collectively make up for an entire network structure that may easily cover a few hundred alliances or even more. Following from this focus on a global network structure, we will focus on Betweenness Centrality (BC) that reflects global centrality. Such a global network structure differs from a firm's individual ego-network, or 'local' network, and its associated degree centrality.

The paper proceeds as follows. The next section presents the theoretical framework and develops four hypotheses. Next we describe the data, variables and methods, and then present our empirical results. In the final section we conclude and discuss the implications of our findings.

2. Theory and hypotheses

2.1. Network position: betweenness centrality (BC)

Betweenness centrality (BC) views an actor as being in a favoured position to the extent that it falls on the geodesic paths between other pairs of actors in the network. That is, the more companies depend on a focal firm to make connections with other companies, the higher the BC of the focal firm becomes. Such a position offers focal firm strategic benefits such as opportunities for brokerage, faster access to diverse and non-redundant information but also visibility as well as power in controlling the flows of information and resources throughout the network (Burt, 1992). As a consequence, a position with high BC will enable firms to extract extraordinary returns from its attractive and powerful position in the network. BC is also of particular relevance in an innovation-based setting as here, an increase in a firm's BC will increase the likelihood of being at the crossroads of key information and knowledge flows through the networks. In this way, BC elevates the potential for recombination that contributes to a firm's innovation performance (Gilsing et al., 2008). Apart from acquiring information, BC also offers room for sending information and the build-up of power. Within an innovation context, a high BC may, for example, support central players in setting and/or maintaining technological standards in their respective industries (Rosenkopf and Padula, 2008).

2.1.1. Antecedents of changes in BC

Burt (1991) suggests that the causal force behind centrality lies in the direct and indirect 'demand' by alters for relations with a focal actor. This is in line with social exchange theory suggesting that a firm must have something of value to offer in order to become or stay attractive to others (Blau, 1964; Emerson, 1962). The implication for inter-firm collaboration is that for a firm to become more central, it must be considered as attractive enough for collaboration in the eyes of others. We refer to what a focal firm has to offer as its possession of *resources* that make others desirous of collaboration. However, whereas

¹ An alternative measure for centrality in a global network structure is formed by closeness centrality, which measures the average number of steps between a focal firm and partners of the partners. In this way, it emphasizes more the potential that such centrality offers for access to other partners but much less the strategic opportunities for brokerage and/or power, as offered by betweenness centrality. Degree centrality forms a local network centrality measure that does not fit with the focus of this study on a global (large scale) network structure.

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