



The influence of supply network structure on firm innovation



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ABSTRACT

In this study, we examine the structural characteristics of supply networks and investigate the relationship between a firm's supply network accessibility and interconnectedness and its innovation output. We also examine potential moderating effects of absorptive capacity and supply network partner innovativeness on innovation output. We hypothesize that firms will experience greater innovation output from (1) higher levels of supply network accessibility and supply network interconnectedness, (2) the interaction between the levels of these two structural characteristics, (3) the moderating role of absorptive capacity on supply network accessibility and the moderating role of supply network partner innovativeness on supply network interconnectedness. Supply network partner relationships are drawn in the context of the electronics industry using data from multiple sources. We use social network analysis to create measures for each supply network structural characteristic. Using regression techniques to test the relationship between these structural characteristics and firm innovation for a sample of 390 firms, our findings suggest that supply network accessibility has a significant association with a firm's innovation output. The results also indicate that interconnected supply networks strengthen the association between supply network accessibility and innovation output. Moreover, the influence of the two structural characteristics on innovation output can be enhanced by a firm's absorptive capacity and level of supply network partner innovativeness. By addressing the need for deeper structural analysis, this study contributes to supply chain research by accounting for the embedded nature of ties in supply networks, and showing how these structural characteristics influence the knowledge and information flows residing within a firm's supply network.

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1. Introduction

Supply chains manifest networks that are comprised of not only a focal firm's direct ties to each of its supply network partners (e.g., suppliers and customers), but also its indirect ties to partners of the firm's direct partners (Choi et al., 2001). Both anecdotal evidence and research on supply networks highlight the operational benefits of effectively managing a supply network. Firms such as Toyota and Schneider Electric have been creating and reevaluating their supply networks to maintain efficiencies in inventory, improve product quality, enhance delivery performance, mitigate supply chain

disruptions and enhance profitability (Dyer and Hatch, 2004; Voxant FD Wire, 2009).

Besides these operational benefits, the supply network of a firm has also been viewed as a source of innovation. For example, Procter and Gamble (P&G) has set an imperative of sourcing innovation from outside the firm. P&G's CEO, A.G. Lafley, confirmed this imperative in 2002 by stating "we will acquire 50% of our technologies and products from outside P&G" (Huston and Sakkab, 2006). These sources included amongst others, consumers, universities and suppliers. Examples are also aplenty in knowledge-intensive industries such as electronics. For instance, the CEO of Direct Methanol Fuel Cell Corporation (DMFCC) announced that the firm "has been establishing a global network of suppliers to manufacture fuel cartridges and other fuel cell products" (PR Newswire, 2007). In particular, the announcement cites the role of its supplier, Tyco Electronics Corporation, in developing and commercializing the innovation on fuel cell technology. Similarly, in 2012, Dell, with the help of its reverse logistics provider GENCO, has initiated innovation in products and processes with several of its suppliers (Gilmore, 2012). In

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line with these examples, research has also conceptualized a firm's partners as sources of innovation and empirically examined the role of partner integration into innovation and new product development activities (Azadegan et al., 2008; Choi and Krause, 2006; Dyer and Nobeoka, 2000; Von Hippel, 1988).

However, little is known about the underlying structural characteristics of a firm's supply network and whether these characteristics have any influence on firm innovation output. Several supply chain researchers have emphasized the value in incorporating network structure when considering firm innovation and performance implications (Autry and Griffis, 2008; Bernardes, 2010; Choi and Kim, 2008). A recent research note by Narasimhan and Narayanan (2013) discusses the role of structural characteristics of a firm's supply network on innovation. The note also emphasizes the role of absorptive capacity, in integrating information flows from supply network partners, to facilitate innovation output. Specifically, absorptive capacity reflects a firm's ability to recognize, assimilate, leverage, and deploy the available external knowledge (Cohen and Levinthal, 1990). Moreover, the emerging paradigm of open innovation suggests that innovations are also derived outside a firm's internal endeavors, and that greater, more novel learning is often gained from external sources (Chesbrough, 2003). Accordingly, firms are recognizing the advantages of leveraging the innovativeness of their supply network partners to influence their innovation output. Specifically, *supply network partner innovativeness* reflects the magnitude of available knowledge residing in a firm's supply network partners (Azadegan et al., 2008).

Our study builds on the conceptualization presented in extant research and empirically addresses two interrelated research questions: *First, what is the association between the structure of a firm's supply network and its innovation output?* Specifically, we examine two important structural characteristics of supply networks: *supply network accessibility* – the speed and effectiveness of information and knowledge access opportunities between a firm and its supply network – and *supply network interconnectedness* – the extent to which a firm's supply network partners are inter-linked. *Second, what moderating role does a firm's absorptive capacity and its supply network partner innovativeness play in the association between the structural characteristics of a firm's supply network and its innovation output?* To empirically test the hypothesized relationships, we collected firm-level data from several archival sources that included data on buyer–supplier relationships, alliances, and patenting activity and used social network analysis to develop the structural characteristics.

We contribute to the literature on examining a firm's supply network partners as a source of innovation in the following ways. First, a firm's level of innovation output is a by-product of its knowledge creation activities and often results in inventions and commercialization that reflect advancements over existing technology or practices. Previous research recognizes a firm's partners as sources of innovation, with firms tapping into the knowledge of their partners (Dyer and Nobeoka, 2000; Von Hippel, 1988). Further, other scholars have argued the need for future research using a more comprehensive structural analysis that accounts for the embedded nature of knowledge among members in the supply network (Kim et al., 2011; Villena et al., 2011). Moreover, prior research has conjectured that the way a firm's supply network is structured, formally termed as structural characteristics, will bear influence on its innovation performance, and have therefore called for future research to empirically examine and test such conjectures (e.g., Autry and Griffis, 2008). We extend these stances by specifically examining the structural characteristics of a firm's supply network and its association with innovation performance by taking a more holistic view of firms that are embedded in a supply network, rather than the traditional dyadic view. In this regard, we consider the influence of two key structural characteristics in a supply network

on innovation: supply network accessibility and supply network interconnectedness.

Second, in addition to addressing the influence of structural characteristics of a supply network on innovation, we also examine the moderating role of two critical knowledge variables, the presence of which may strengthen the relationship between the two structural characteristics and innovation output. We examine the moderating role of *absorptive capacity*, represented by the firm's research and development (R&D) intensity. We also consider the role of *supply network partner innovativeness*, that is, the magnitude of available knowledge or more formally, the average level of patent stock that exists among a focal firm's supply network partners. While the structural characteristics of a supply network facilitate knowledge and information flows between partners, both knowledge availability in the network and the capability to combine the knowledge may enable firms to translate the benefits of high levels of supply network accessibility and supply network interconnectedness into higher innovation output. Our findings confirm this conjecture, suggesting that opportunity exists for firms in knowledge-intensive industries such as electronics – which outsource parts of their product development to supply network partners – to supplement growth in their innovation output through leveraging its absorptive capacity and the innovativeness of its supply network partners (Dedrick et al., 2010). Overall, taking the main effects of structural characteristics together with the moderating effects of knowledge variables provides a coherent theoretical framework to potentially extend the literature on the influence of the structural characteristics of supply networks on innovation.

The remainder of this study is organized as follows. In Section 2, we discuss the literature on innovation, supply chain management, and networks and develop hypotheses relating supply network structural characteristics to firm innovation output. We describe our research methodology in Section 3 and our empirical analysis and results in Section 4. In Section 5 we discuss our research findings, implications for theory and practitioners, and future research opportunities. Lastly, we conclude our study in Section 6.

2. Theoretical background and hypotheses development

Buyer–supplier relationships have been conventionally viewed as linear or dyadic structures, rather than as a network (Kim et al., 2011). However, given a supply chain's complex and increasingly interdependent nature, a network approach provides a richer view by considering the various interactions taking place among firms in the supply network (Borgatti and Li, 2009; Buhman et al., 2005; Choi et al., 2001). In contrast to the conventional approach, where firms are viewed as autonomous and self-reliant entities striving to use their resources to compete with other such entities, the network approach focuses on the structural elements of the firm and its inter-organizational network partners (Granovetter, 1985). We define a supply network as an inter-linked network of firms consisting of manufacturers, suppliers, customers, third party service providers, and alliance partners that interact to execute the supply chain activities of the firm. The various firms in the supply network are generally referred to as supply network partners of a given focal firm in the network.

The theory on social networks helps explain the benefits derived by a firm viewed as embedded within a larger network of structurally interdependent partners. This lens emphasizes that the benefits accrued from access to knowledge, resources, and information available within a network of relationships can lead to an organizational advantage (Granovetter, 1973). Nahapiet and Ghoshal (1998) elaborate on this notion across three dimensions: cognitive, relational, and structural. The cognitive dimension refers

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