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The double-edged sword of technological diversity in R&D alliances: Network position and learning speed as moderators

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ABSTRACT

Research on alliances has recognized the bright and dark sides of technological diversity between alliance partners. We extend this line of research by offering a model that examines how network centrality and learning speed shape the relationship between technological diversity and market performance. We tested the model by using a large sample of 769 firm-year observations from U.S. biotech, pharmaceutical, and medical device industries, spanning the period from 1990 to 2006. The results reveal that the degree of technological diversity between alliance partners exhibits an inverted U-shaped relationship with firm performance. In addition, this relationship is positively moderated by network centrality and learning speed.

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1. Introduction

To address volatile environments, firms leverage research and development (R&D) alliances as a strategic mechanism for exploring new capabilities or technologies, sharing risks, and gaining synergy (Haas & Hansen, 2007; Meuleman, Lockett, Manigart, & Wright, 2010; Shipilov, 2009). R&D alliances have proliferated in technology-intensive industries (Lin, Yang, & Arya, 2009; Meuleman et al., 2010; Mowery, Oxley, & Silverman, 1996), because the resources of interest in interfirm R&D collaborations allow firms to improve their technological development (Rodan & Galunic, 2004). When firms collaborate with partners who are sufficiently differentiated in technological domains from themselves, both parties complement each other in producing or commercializing products (Lin, Yang, & Demirkan, 2007; Park & Zhou, 2005; Yang, Phelps, & Steensma, 2010). Although R&D alliances provide an opportunity to tap into diverse technological capabilities, they do not guarantee superior performances (Luo & Deng, 2009; Sampson, 2007; Wadhwa & Kotha, 2006).

Scholars have recognized the ramifications of technological diversity between allied firms on firm performance. In a study on the telecommunications equipment industry, Sampson (2007) indicated that the relationship between technological diversity and innovative performance is curvilinear. Considering the complex nature of a curvilinear relationship, Miller (2006) suggested that researchers should explore whether this relationship is contingent on certain organizational characteristics (Schilke & Goerzen, 2010). In particular, we focus on two characteristics that are crucial in coping with technological diversity (Lai & Weng, 2013). Given that firms differ in their learning capability based on prior experience with different technological knowledge, they vary with respect to the costs of understanding and assimilating new technological knowledge (Zander & Kogut, 1995). Moreover, once a firm forms an alliance with another firm, it is embedded in a network of interfirm relations (Gulati, 1999). The resources available to a firm is a function of its position within the network structure (Tsai & Ghoshal, 1998), and an advantageous position will allow the firm to mobilize and tap into potentially useful resources in absorbing new knowledge (Gilsing, Nooteboom, Vanhaverbeke, Duysters, & van den Oord, 2008; Lee, Lee, & Pennings, 2001). Accordingly, we theorize that a firm's network and learning characteristics may alter the effect of technological diversity on firm performance. To elucidate the moderating roles of these characteristics, we use social capital theory and absorptive capacity theory as a theoretical lens.

Social capital theory emphasizes the benefits derived by actors

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from the network structure and elucidates how these benefits, or "structural social capital," can influence knowledge exchange and combination by generating trust, reciprocity norms, and a shared identity (Tsai & Ghoshal, 1998). As a type of structural social capital, "network centrality" indicates a firm's structural proximity to all other firms in the network (Zukin & DiMaggio, 1990). It denotes a firm's position in the entire pattern of ties comprising a network (Stam & Elfring, 2008). Gulati (1999) considered a firm's network location as the most important network variable while studying inter-firm learning. Lechner, Frankenberger, and Floyd (2010) further confirmed the effect of the interaction between network centrality and organizational learning on firm performance. Hence, we expect that network centrality may act as a moderator to the relationship between technological diversity and performance.

Absorptive capacity has been widely adopted by studies that focus on technological diversity (Miller, 2006; Lin, Wu, Chang, Wang, & Lee, 2012). Its basic premise is that the extent to which firms can learn from external sources depends largely on their capability to absorb knowledge (Cohen & Levinthal, 1990). This capability represents the potential for transforming technological diversity into performance outcomes (Sampson, 2007). Given that absorptive capacity is multidimensional (Zahra & George, 2002), a research gap remains to be addressed. Specifically, since absorptive capacity and organizational learning evolve together (Lane, Koka, & Pathak, 2006), scholars have explicitly emphasized that absorptive capacity stems from learning experience (Camisón & Forés, 2010). Nevertheless, research on technological diversity has not examined the moderating role of learning experience. Prior learning experiences enhance learning efficiency by enabling firms to acquire new knowledge rapidly and economically (Pérez–Nordtvedt, Kedia, Datta, & Rasheed, 2008). The degree to which firms can quickly absorb new external knowledge is reflected in their learning speed (Pérez-Nordtvedt et al., 2008). Consequently, a firm with a high learning speed has an inherently greater capacity than other firms to efficiently combine existing knowledge with new knowledge (Wu, Lee, & Lin, 2014). It is plausible that a firm's learning speed is an indicator of the speed with which it assimilates novel knowledge from its partners. Hence, this study identifies learning speed as another key moderator.

This study examines the performance implications of technological diversity and aims to fill some research gaps by identifying network centrality and learning speed as crucial moderators. Although previous studies have explored technological diversity between firms in R&D alliances (Sampson, 2007; Yang et al., 2010), these analyses have been limited to a single industry. To increase the generalizability of our findings, we test our conceptual model (see Fig. 1) by using a sample of 769 R&D alliances from biotech, pharmaceutical, and medical device industries in the United States during 1990–2006. Our findings reveal that the extent of technological diversity between a focal firm and its R&D alliance partner has a curvilinear relationship with the market-based performance of the firm. Further, the firm's network centrality and learning speed moderate this relationship.

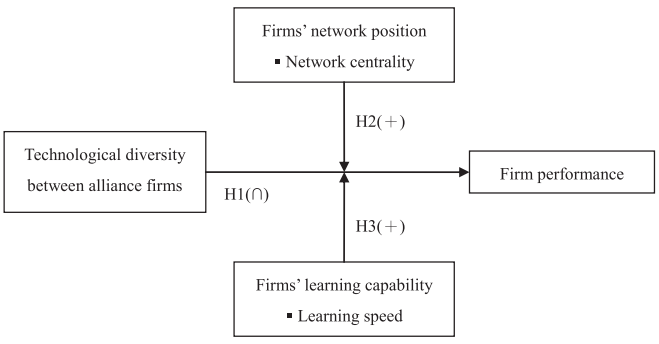

Fig. 1. Theoretical model of technological diversity and firm performance.

2. Theoretical foundation and hypotheses

Firms that form R&D alliances typically aim for substantial technological advances and product innovations through the acquisition of knowledge and capabilities from partner firms (Hagedoorn, 1993; Hamel, 1991; Mowery et al., 1996). The reason behind R&D alliance formation is supported by the heterogeneous knowledge bases that characterize firms and the fact that this heterogeneity originates from a process of cumulative learning (Dosi, Nelson, & Winter, 2000). The resource-based view (RBV) of a firm suggests that such heterogeneity is a source of competitive advantage (Barney, 1991; Conner & Prahalad, 1996; Wernerfelt, 1995). The traditional RBV tends to focus on resources within the firm, but this perspective can be extended to the alliance context. Das and Teng (2000) employed the RBV to provide a comprehensive overview of strategic alliances. The RBV rationale of alliance management emphasizes value maximization rather than cost minimization. The specific firm resources involved in collaboration include financial resources, market power, technological assets (e.g., Ahuja, 2000), and social position. Research focuses on resource exchange, in which firms exchange complementary resources (Burgers, Hill, & Kim, 1993), especially knowledge (Roper & Crone, 2003; Teece, 1998).

Certain pioneering contributions facilitated the burgeoning research on interfirm knowledge transfer (e.g., Kogut, 1988; Teece, 1986). Subsequent studies have addressed the subject of knowledge transfer between alliances, including aspects such as governance modes (Aggarwal, Siggelkow, & Singh, 2011), partner selection (Lin et al., 2009; Meuleman et al., 2010), and knowledge-transfer mechanisms (Inkpen, 2008; McEvily & Marcus, 2005). Partner-selection studies have recently given rise to a stream of research that considers a firm's alliances to be a portfolio, with a focus on the diversity of alliance partners (Jiang, Tao, & Santoro, 2010; Sampson, 2007). Similar to the examination of network diversity conducted by Goerzen and Beamish (2005), this notion of alliance-partner diversity is reflective of the degree of variance in partners' resources, capabilities, knowledge, and technological bases (Jiang et al., 2010).

Following previous research (e.g., Mowery et al., 1996; Sinkula, Baker, & Noordewier, 1997), this study extends organizational learning into an alliance setting. Organizational learning theorists have argued that alliances provide a platform whereby firms can learn new skills and capabilities that considerably enhance their capability to innovate, take risks, and develop new revenue streams (Huber, 1991; Lyles & Salk, 1996). Collectively, inter-organizational learning facilitates synergistic and superior performance because it enables firms to develop new in-house capabilities while acquiring novel capabilities externally. One aspect of interfirm learning that has received attention in the alliance literature is absorptive capacity, particularly a firm's absorptive capacity for learning from its alliance partners (Mowery et al., 1996). As previously discussed, absorptive capacity theory inspires this study to identify learning speed as a moderator of the technological diversity–performance relationship. Moreover, based on the social capital theory and network research by Gulati (1999) and Lechner et al. (2010) that associated network location with organizational learning, we argue that a firm's network centrality is another moderator.

The "bright side" of alliance-partner diversity has been acknowledged in the literature (Jiang et al., 2010; Park & Zhou, 2005). The risks and costs that accompany increased

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