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Technological relatedness, boundary-spanning combination of knowledge and the impact of innovation: Evidence of an inverted-U relationship

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ABSTRACT

Our paper proposes that corporate technological relatedness, or the degree to which business units within a corporation utilize similar technological knowledge, has both positive and negative effects on corporate R&D activities. On the one hand, business units that employ similar technological knowledge have better absorptive capacity to source knowledge from each other. On the other hand, a higher level of technological relatedness means that each business unit possesses fewer opportunities to gain new knowledge not known to other units, thus promoting path dependence to each other. Using a patent data analysis of 201 firms in R&D-intensive industries, we examine the effects of corporate technological relatedness on within-firm knowledge flow, boundary-spanning combinations of prior knowledge, and innovation impacts.

1. Introduction

In strategic management theory, the resource-based view suggests that firms should avoid operating business portfolios that require vastly different kinds of resources and capabilities. According to this view, related diversifiers that exploit identical resources and capabilities across different businesses perform better than unrelated diversifiers unable to create synergistic effects. Thus, this view recommends that firms develop core competences to excel in a small number of aspects along value chain activities and join industries where they can exploit those competences. This theoretical argument has generated many empirical studies that vary with respect to the kinds of resources examined and the methodological approaches taken to measure relatedness among different business units.

Recent studies have suggested that achieving economies of scope based on technological knowledge is one of the most appropriate reasons for diversification (Miller, 2004; Robins & Wiersema, 1995). The costs associated with additional application of technological knowledge within a corporate boundary are trivial. At the same time, transferring knowledge through a market mechanism is cumbersome, since devising contracts sophisticated enough to prevent opportunistic behavior by both knowledge seller and buyer is difficult. In line with this argument, recent empirical studies have demonstrated that firms creating synergy based on technological knowledge exhibit superior performance than those do not (Miller, 2006; Silverman, 1999; Tanriverdi & Venkatraman, 2005). These studies imply that corporation with business units of similar technological expertise will perform better than those with business units that pursue different technological paths.

Although the similarity of technological expertise among a corporation's subunits may create synergy in R&D activities, excessive technological overlap may undermine a firm's R&D performance. Within the context of overseas R&D networks of multinational corporations, Song and Shin (2008) argued that R&D units have little incentive to source knowledge from each other when they have similar technological capabilities, thereby learning little from each other. On the other hand, innovations

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generated by combining diverse technological expertise tend to have a wider impact on ensuing technological evolution, than do those originating from a narrow range of technological expertise (Rosenkopf & Nerkar, 2001; Yayavaram & Ahuja, 2008). These studies imply that corporations with both similar and diverse subunits, in terms of technological expertise, may exhibit higher R&D performance than do those with little technological variation among their subunits.

In this paper, we investigate how technological relatedness among corporate subunits, or the degree to which corporate subunits utilize similar technological knowledge, affect a firm's innovation activities and performance. We hypothesize a positive linear effect of technological relatedness among the subunits on knowledge flow within a corporate boundary due to superior absorptive capacity (Cohen & Levinthal, 1990) among the subunits. As technological relatedness facilitates knowledge flow among subunits, these subunits will have more opportunities to learn from each other. However, a high level of technological relatedness entails a negative effect on corporate R&D performance in that subunits are less likely to introduce new knowledge elements to each other. We argue that at an extremely high degree of technological relatedness, such negative effect prevails over the positive effect of increasing knowledge flow. We support this argument by empirically showing that technological relatedness has an inverted-U relationship with the frequencies of technological boundary-spanning combination of knowledge elements and with R&D performance.

Our paper uses patent data to measure within-firm knowledge flow and the impact of innovations created by firms. In addition, we employ Silverman's (1996) data that link patent classes and SIC industries to construct technological relatedness measures, and to assess boundary-spanning innovation. We employ a robust generalized linear model and negative binomial regression to investigate the effects of technological relatedness. Statistical findings based on 201 firms in R&D intensive industries support the argument that technological relatedness has both positive and negative effects on corporate R&D activities.

2. Theory and hypotheses

Theoretically, the resource-based view (Barney, 1991; Wernerfelt, 1984) has produced a compelling argument regarding how relatedness among different businesses may enhance a firm's performance. According to the resource-based view, firms sharing strategic resources among several businesses have advantages of scope economies (Teece, 1980). Economies of scope refer to the cost advantages arising when a firm utilizes a particular resource across several businesses (Panzar & Willig, 1981). By sharing significant resources across different business activities, firms with related diversification can increase revenues while saving potential costs associated with developing and applying new types of resources (Lubatkin & Chatterjee, 1994).

Although economies of scope are an important motive for diversification, it alone does not explain why firms resort to diversification instead of licensing or joint venture. Firms might be able to take advantage of economies of scope better by licensing assets to third parties or by sharing them with partners through joint ventures, when the bureaucratic costs associated with diversification are non-trivial. Thus, diversification becomes an attractive option when assets with potential economies of scope cannot be transferred to third parties by market mechanisms (Teece, 1980).

In general, firms face a high level of difficulty in transacting technological knowledge in the market (Teece, 1980; Von Hippel, 1994). When two independent parties buy and sell technological knowledge in the market, they should be concerned about the possibility of opportunistic behavior by each other. Without identifying the contents of technological knowledge, buyers would not be able to assess the potential value of a seller's technological knowledge. However, sellers would not reveal the contents of technological knowledge prior to transaction because doing so may incur opportunistic behavior by the buyers. Therefore, transaction costs associated with selling technological knowledge in the market may exceed the bureaucratic costs associated with sharing technological knowledge through diversification.

Technological relatedness, or the similarities among business units in terms of technological expertise, will become increasingly higher as corporations continue to diversify in order to exploit technological knowledge in house. Robins and Wiersema (1995) found that corporate performance is higher for firms that have diversified into technologically-related industries than for those that diversified into technologically-unrelated industries. Indeed, corporations with a higher degree of technological relatedness among subunits may have several advantages that contribute to a firm's R&D activities. Business units with similar technological expertise will have higher absorptive capacity to learn from each other (Cohen & Levinthal, 1990). According to Lane and Lubatkin (1998), the ability of an actor to learn from the other is high when two actors have similar knowledge base. Szulanski (1996) showed that a lack of absorptive capacity among business units is one of the major impediments to within-firm knowledge transfer. Darr and Kurtzberg (2000) showed that two stores transfer knowledge with each other more frequently when the strategic similarities of the stores are high. Song and Shin (2008) also argued that multinational corporations are more likely to source knowledge from their host countries when the firms' technological profiles are similar to those of the host countries. Thus, corporate subunits that have built similar technological expertise will have higher absorptive capacity to learn from each other, which can enhance knowledge flow within a corporation.

Technological relatedness will not only enhance absorptive capacity among business units, but will also increase the motivation of each subunit to search for technological solutions within corporate boundary. The sizeable costs associated with search beyond organizational boundaries often directs a firm's primary search efforts to the body of knowledge within the corporation (Rosenkopf & Nerkar, 2001; Stuart & Podolny, 1996). It is easier to transfer complex knowledge difficult to codify within the organizational boundary, than through the contexts of markets (Kogut & Zander, 1992). Transferring valuable knowledge across firms risks opportunistic behavior between knowledge senders and recipients (Grant, 1996; Teece, 1980). As a result, Singh (2005) found that within-firm knowledge flow is high because individual collaborative networks are more likely to be created within firms rather than across firms. Thus, a subunit is more likely to attempt to search for a solution in other subunits than outside the corporate boundary, if those subunits are perceived as having dealt with similar technological problems before and thus have a potential solution.