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A patent portfolio-based approach for assessing potential R&D partners: An application of the Shapley value☆

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ABSTRACT

We propose a patent portfolio-based approach for assessing potential R&D partners that can consider the inter-partner resource fit in the assessment process. The concept of an integrated patent portfolio is suggested and its value is designed to reflect the resource fit between potential R&D partners. The Shapley value is applied to assess the contribution of each potential partner to the value of the integrated patent portfolio. A case study of a lighting control system is presented to show the feasibility and advantages of our method. Overcoming the weakness of individual capability-focused evaluation of potential R&D partners, our method can better inform decision makers and experts in the partner selection process by enabling more comprehensive assessment of potential R&D partners.

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1. Introduction

As the importance of R&D cooperation has increased, partner selection has become a strategic issue for firms (Cowan et al. 2007) since it affects the success of the partnership (Dodgson, 1992; Das and Teng, 2003; Arranz and de Arroyabe, 2008). Careful screening is essential to select the right partners (Dacin et al. 1997), including the entire process from the identification of candidates to the evaluation of their quality (Nijssen et al. 2001). This process inherently involves complex decision-making problems with multiple criteria and uncertainty on the future performance of the partnership. Moreover, the difficulty and the importance of the partner selection process are even more significant given the rapidly changing business environment and the prevalence of cross organizational collaboration. Consequently, recent years have witnessed an increasing need for appropriate data and methods to facilitate the partner selection process.

A large body of literature has endeavored to provide better understanding and implications of assessing and selecting R&D partners by investigating motivations of cooperation (Bayona et al. 2001; Verspagen and Duysters, 2004), determinants of success (Holmberg and Cummings, 2009) and failure (Kogut, 1989; Lhuillery and Pfister, 2009), and heterogeneity according to the partner type (Arranz and de Arroyabe, 2008) and sector (Hagedoorn, 1993). The theoretical and empirical findings in previous studies have accentuated the importance of partner selection and have offered important criteria in identifying appropriate partners. However, a significant drawback is that they have used post-analysis approaches relying on econometric data and/or expert knowledge after performing R&D cooperation. There has been relatively little concern about the methodological support for decision-making in the partner selection process despite the urgent need for methods in practice to reduce the complexity of the partner selection process.

Emphasizing the need for methodological support, some recent studies have attempted to systemize the tasks involved in the partner selection process. While the specific methods suggested by previous studies vary, they have commonly been based on patents as the primary data source. The detailed information conveyed in the patents such as technical, bibliometric, and citation information can support several tasks in the partner selection process. For instance, (Jeon et al. 2011) applied text-mining techniques to patent claims to identify potenital partners who possess the desired technology. (Geum et al. 2013) designed literature-based indexes based on the bibliometric and citation information of scientific publications and patents to search for and assess appropriate R&D partners. Although the validity and utility of a patent-based approach in the partner selection process have proven to be successful to some extent, these studies have a limitation of only considering potential partners' capabilities individually. Because R&D cooperation is an interactive process among partners, both the capabilities

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of individual participants as well as their compatibility should be examined in the partner search and partner choice process (Gemünden et al. 1999).

From a resource-based point of view, the resource fit between R&D partners has been highlighted as a main motive to cooperate and a crucial factor to create synergy from the cooperation (Das and Teng, 2000). However, to the best of our knowledge, few methodological attempts have been made to assess the resource fit between potential R&D partners. Focusing on resource complementarity, (Wang, 2012) conducted a series of patent analyses to identify complementary technologies for developing particular products and discussed possible partners based on their technological complementarity. However, that work still has some drawbacks in considering resource fit in the partner selection process as follows. First, resource complementarity is an important dimension of resource fit but not the only one. While cooperation with those who have complimentary resources can be a means of filling the resource gap and of creating unexpected innovation from combining unrelated knowledge in different domains (Das and Teng, 2000; Barney, 1991; Rothaermel, 2001), there needs to be preliminary knowledge in the related domains to absorb and utilize the external knowledge (Lane and Lubatkin, 1998). Therefore, R&D partners should have resources that are not only complementary but also similar to each other to some extent (Cohen and Levinthal, 1990). A methodological framework for the partner selection process needs to offer a comprehensive view of resource fit among partners with the capability of reflecting resource complementarity as well as resource similarity. Second, resource complementarity has been qualitatively investigated between two firms by comparing their technological competitiveness in the target technological fields (Wang, 2012). However, R&D cooperation often involves multiple partners, where a complicated task of comparing multiple resource portfolios is required to investigate resource fit among multiple partners. A quantitative approach for modeling and assessing resource fit can be useful to reduce such complexity.

This research proposes a way to consider the inter-partner resource fit in assessing potential R&D partners. A patent portfolio was chosen for this research because it is a representative way of exploring and managing technological resources (Brockhoff, 1992; Ernst, 1998; Ernst, 2003). It enables us to assess firms' competitive positions in a particular technological field as well as examine the composition of their technological resources (Ernst, 2003; Lin et al. 2006). At the heart of our approach for utilizing patent portfolios in the partner selection process is (1) the concept of an integrated patent portfolio in which its value is so designed that the resource fit between potential partners is reflected; and (2) the application of the Shapley value to assess the contribution of each participant to the value of the integrated patent portfolio. The Shapley value is a solution concept in cooperative game theory (Shapley, 1953; Roth, 1990) that offers answers about how important each player is to the overall cooperation and what payoff each player can reasonably expect. Thus, regarding R&D cooperation as a cooperative game to produce an integrated patent portfolio, the application of the Shapley value can present a useful and convenient instrument for evaluating the importance of each participant in creating the value of an integrated patent portfolio.

This paper is organized as follows. Section 2 presents the related work on partner selection in R&D cooperation, patent portfolio analysis in managing technological resources, and background of the Shapley value. The proposed approach is explained in Section 3, and illustrated in Section 4 with the case of a lighting control system. Finally, the conclusions are presented in Section 5.

2. Background

2.1. Partner selection in R&D cooperation

Given the great uncertainty about the future business environment (Wheelwright and Clark, 1992; Freeman and Soete, 1997) and the growing need for multidisciplinary knowledge to handle such uncertainty in R&D decision-making, many firms have engaged in R&D cooperation to incorporate multiple external sources of knowledge (Hagedoorn, 2002). R&D cooperation allows a firm not only to access external resources but also to reduce the innovation time span, share the risks associated with the innovation, and increase the performance of the innovation (Hagedoorn, 1993; Hagedoorn, 2002; Laursen and Salter, 2006; Leiponen and Helfat, 2010).

While the strategic importance of R&D cooperation is apparent, the formation and performance of R&D cooperation largely depend on the partners' capability and attributes. Many failures in R&D cooperation have resulted from incompatibility between partners (Ariño, 2003; Büyüközkan et al. 2008), so choosing the right partners is the most significant factor for the success of R&D cooperation (Cowan et al. 2007; Dodgson, 1992; Das and Teng, 2003). With respect to different purposes of cooperation, from minimizing transaction costs to exploiting complementary resources between partners (Das and Teng, 2000; Kogut, 1988), a vast amount of literature has investigated partners' characteristics as determinants of inter-firm alliances, such as partners' attributes (e.g., firm size, R&D intensity, and sales) (Veugelers, 1997; Becker and Dietz, 2004), inter-firm trust and mutual interest (Kanter, 1994; Inkpen and Currall, 1997), cultural fit (Littler et al. 1995), and the resource fit between partners (Das and Teng, 2000; Barney, 1991; Rothaermel, 2001; Lane and Lubatkin, 1998). The results and insights from these studies have accentuated the importance of partner selection in successful R&D cooperation and have suggested a set of important criteria to evaluate potential R&D partners.

Although the theoretical and empirical literature has facilitated our understanding of the role of partners' characteristics in R&D cooperation, many prior studies have centered on the explanation of R&D cooperation after it was established. As a consequence, the literature has failed to support the decision-making process involved in partner selection with a structured process and formalized methods that are specific to partner selection. Many firms have relied heavily on experts' knowledge and experience when searching for and evaluating potential R&D partners. However, the search for an external knowledge source is not without cost and can be time-consuming, expensive, and laborious (Laursen and Salter, 2006). Moreover, the expert-based approach becomes more costly with the trend toward open innovation (Chesbrough, 2003) where a pool of potential R&D partners is extremely extended in terms of regions and industrial sectors. In this circumstance, decision makers in the partner selection process need assistance through quantitative data and appropriate methods to make the right decisions.

In more recent years, some studies have attempted to systemize the tasks involved in the partner selection process. Patents have often been employed as the data source to search for candidates that might be scattered all over the world and to assess technological and relational capabilities of these candidates. For example, (Jeon et al. 2011) explored appropriate partners that possess the desired technologies to meet particular technological requirements by applying text-mining techniques to patent documents in the context of technological mediation. (Geum et al. 2013) also suggested a data-based approach to search for appropriate R&D partners. By analyzing academic publications and patent data, they designed 14 relevant indexes to reflect desirable partner characteristics. These efforts to derive useful information from patent data for decision-making in the partner selection process have highlighted the validity and utility of methodological support. However, these studies have failed to address the resource fit between potential partners, even though resource fit has been emphasized as an important requirement of R&D partners, thus motivating the current study.

From a resource-based point of view, a goal of R&D cooperation for a firm is to access external resources, in particular technological resources that are difficult for one firm to possess by itself in a cost-effective way. Hence, the incentive to cooperate and the synergy from the cooperation are likely to increase as resources of the partners fit well with each other (Das and Teng, 2000; Barney, 1991; Rothaermel, 2001; Lane

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