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Geographic dispersion and co-location in global R&D portfolios: Consequences for firm performance

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ABSTRACT

We examine how the ways in which firms geographically configure their global portfolios of R&D units influence the effectiveness of firms' own R&D investments and of external technical knowledge in enhancing firm performance. Our analysis indicates that the strength of these effects depends on the extent to which firms spread their R&D units *across* countries (*geographic dispersion* of R&D) and the extent to which firms establish multiple R&D units *within* each country (*co-location* of R&D). We show that geographic dispersion and co-location are associated with distinct value creation and value capture mechanisms and in turn lead to different performance outcomes. Although geographic dispersion enhances the effects of a firm's own R&D on its performance, R&D co-location limits such effects. These relationships are reversed when we consider the effects of external technical knowledge on firm performance. R&D co-location, rather than geographic dispersion, is what renders the exploitation of external knowledge more effective in enhancing firm performance. Our results suggest that future research should shift its focus from the degree of R&D globalization to *how* a portfolio is globalized and geographically structured.

1. Introduction

In a quest to become more competitive, firms are increasingly establishing R&D units abroad. Although global R&D portfolios may assist firms in creating value (Phene and Almeida, 2008; Lahiri, 2010; Piening et al., 2016), they come with significant challenges and costs (Alcácer and Zhao, 2012; Berry, 2014; Kim, 2016). The literature acknowledges the positive and negative consequences of global R&D portfolios for firm performance, but it does not predict which effect is likely to dominate and through what mechanisms. Incomplete knowledge of this phenomenon prompts a need to better conceptualize how firms create and capture value when they conduct R&D in multiple countries rather than in a single market (Teece, 1986). In particular, little is known about whether and how different ways of geographically configuring R&D portfolios may lead to different performance outcomes. We therefore have limited understanding of why some firms succeed in benefiting from global R&D while others do not.

Our study furthers understanding of factors that facilitate or impede the success of global R&D by examining how the geographic configuration of a firm's global R&D portfolio influences the effectiveness of 1) its own R&D investments and 2) external (globally dispersed) technical knowledge in enhancing the performance of the entire firm (rather than just the performance of a given unit that has access to external knowledge).[1] Our study differs from work about the *direct* effect of R&D internationalization on firm performance and the different types of curvilinear relationships (Hitt et al., 1997; Lu and Beamish, 2001, 2004). It also differs from studies that document the benefits of external knowledge within a specific country or between two nations (Andersson et al., 2016; Almeida and Kogut, 1999; Iwasa and Odagiri, 2004) without considering the geographic configuration of a firm's *entire* R&D portfolio. Our study therefore seeks to advance research that suggests that global R&D enables firms to access knowledge from different countries (Cantwell and Piscitello, 2000; Piening et al., 2016; Anand et al., 2005; Kafouros et al., 2012) but has neither theorized nor

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[1] Two other literatures examine how R&D and other factors affect patent output and citations (Griliches, 1989; Penner-Hahn and Shaver, 2005) and how patents affect firm performance (e.g., Hall et al., 2005; Greenhalgh and Rogers, 2007). Although these two literatures inform our analysis and argumentation, our study is situated within a distinct literature that examines the relationships between R&D, external knowledge (spillovers) and firm performance (e.g., Adams and Jaffe, 1996; Hall and Mairesse, 1995; Feinberg and Majumdar, 2001).

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empirically examined how firms can configure R&D portfolios in a way that increases the performance-enhancing effects of their own R&D and of external technical knowledge.

As opposed to single-location studies that disregard how innovating across multiple locations may differ from innovating within a single market, we account for each firm's entire portfolio of R&D units, its location choices across countries, and the ways in which a firm geographically configures its R&D portfolio. To understand sources of heterogeneity in the geographical configuration of R&D, we focus on two distinct dimensions of R&D portfolios that vary significantly across firms: the (global) *geographic dispersion* of R&D, which is defined as how widely a firm spreads its R&D units across countries; and R&D *co-location*, which refers to the placement of several R&D units in each country. Global geographic dispersion reflects the fact that while some firms spread their R&D units across multiple countries, others choose to innovate in only a few countries (Delios and Beamish, 1999; Tang and Tikoo, 1999; Jiang et al., 2016). It thus captures the international geographic scope of R&D portfolios (Kim, 2016). On the other hand, variations in the co-location of R&D units reflect the fact that some firms locate only one R&D unit in a given country while other firms co-locate several R&D units in each country. Co-location therefore captures the geographic concentration of R&D units in a portfolio. Because these two distinct dimensions together reflect the geographic configuration of R&D portfolios both *across* countries and *within* each country, it is important to examine both constructs in a unified framework.

Although the determinants and motives that may lead managers to structure R&D portfolios differently fall outside the scope of this study, we draw from research on value creation and value capture (Kim, 2016; Teece, 1986) to develop a set of hypotheses aimed at explaining how geographic dispersion and co-location influence the effect of a firm's R&D investments and that of external technical knowledge on firm performance. We test our framework by employing a longitudinal dataset on 601 R&D subsidiaries. We model performance outcomes as a function of technical knowledge originating from 25 countries and 28 manufacturing industries, thus capturing not only a firm's entire R&D portfolio but also most of the world's pools of technical knowledge. This approach involves the application of a mapping exercise that enables us to match countries in which a firm maintains R&D units to knowledge pools residing in these locations.

Our study challenges current thinking on the interplay between firm-specific idiosyncrasies and exogenously determined factors and offers new implications for theory by shifting the focus from the degree of R&D globalization to *how* a portfolio is globalized and geographically structured (Jiang et al., 2016). From a theoretical point of view, it advances research on global innovation by specifying the different mechanisms through which the geographic dispersion and co-location of R&D differentially influence the effect of a firm's own R&D and that of external technical knowledge on firm performance. It also extends prior research by considering the performance effects of external knowledge within a global context and by offering a more complete account of how firms benefit from spatially distant knowledge. From a practical point of view, this study can help R&D managers understand trade-offs between dispersion and co-location and thus structure R&D portfolios in a way that optimizes the value added derived from firm R&D and from globally dispersed technical knowledge.

2. Theory

2.1. Global R&D portfolios, external technical knowledge and firm performance

A firm's R&D investment can improve its performance by leading to the generation of new technologies, products, services and processes that may reduce cost, generate revenue and enhance firm competitiveness. However, firm performance is driven not only by a firm's own R&D activities but also by R&D conducted by other organizations (Audretsch and Feldman, 1996; Argyres and Silverman, 2004; Cassiman and Veugelers, 2006; Andersson et al., 2016). The R&D investments of other organizations in a given industry and country lead to the formation of globally dispersed "pools" of ideas and specialist knowledge regarding scientific and technological developments that stimulate spillovers, serve as seeds for creating new technologies and may therefore improve the performance of other firms as well (Feinberg and Majumdar, 2001; Singh, 2007). These industry-country-specific pools of external technical knowledge depend on each country's industrial structure and on the amount and type of R&D undertaken in each industry. They thus differ considerably across countries in terms of characteristics, size and growth patterns.

The channels through which external technical knowledge (spillovers) enhances firm performance include demonstration effects, targeted knowledge searches, reverse engineering, employee mobility, collaborative agreements and other forms of inter-organizational interaction (Audretsch and Feldman, 1996; Coe and Helpman, 1995; Chung and Yeaple, 2008). Nevertheless, environments that feature large pools of external technical knowledge also come with certain disadvantages related to the presence of a large number of R&D-intensive and technologically strong rivals. Hence, while a focal firm can access and benefit from external technical knowledge, such knowledge also benefits organizations that have developed it as well as other competitors. Therefore, it may negatively affect the performance of the focal firm (Kafouros and Buckley, 2008).

Although such technical knowledge is geographically localized and tied to the country in which it is created (Jaffe et al., 1993; Almeida and Kogut, 1999; Chung and Alcácer, 2002), a firm can use its R&D portfolio to achieve proximal access to it (Anand et al., 2005; Chung and Yeaple, 2008; Piening et al., 2016). Accessing, accumulating and bringing together diverse knowledge from multiple locations plays a crucial role in improving a firm's performance by further enhancing technical understanding (Frost, 2001; Kogut and Zander, 1993; Cantwell and Mudambi, 2005) and the development of new capabilities in international markets (Kotabe et al., 2007; Lu and Beamish, 2004; Meyer et al., 2009).

Independent of where knowledge is created, a portfolio of global R&D units provides a firm with opportunities to access technical knowledge but to also combine and transfer such knowledge throughout the organization and between its R&D units (Nobel and Birkinshaw, 1998; Tsai, 2001; Anand et al., 2005; Phene and Almeida, 2008). Nevertheless, the benefits of such spillovers and of knowledge transfer depend on the existence of formal and informal structures and processes that foster knowledge sharing between different R&D units and between these units and their headquarters. This in turn enables a firm to cross fertilize knowledge across different units (Hansen and Lovas, 2004). The literature also acknowledges that despite the above benefits, the internationalization of R&D (or of other functions) involves coordination, collaboration and monitoring costs. It also involves challenges associated with preventing the duplication of R&D projects and with innovating in different intellectual property rights (IPR) regimes. These challenges can overstretch a firm's capacity to manage diversity (Laursen and Salter, 2006; Love et al., 2014) and may require the use of additional costly resources. Hence, prior studies suggest that global dispersion beyond a certain level may have a *direct* negative effect on firm performance (see Hitt et al. (2006) for a literature review).

3. Hypotheses

3.1. Geographic dispersion and co-location in global R&D portfolios

We contend that the effects of (1) a firm's own R&D investments and (2) external technical knowledge on performance are not uniform across all firms but rather vary depending upon the *geographic dispersion* and *co-location* of a firm's global R&D portfolio (Fig. 1). The following sections present a set of hypotheses that specify the relevant