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Top management team international diversity and the performance of international R&D

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ABSTRACT

We investigate how international diversity in Top Management Teams (TMTs) contributes to the effectiveness of geographically dispersed R&D strategies in enhancing innovation performance. Both international work experience and nationality diversity may enhance the effectiveness of geographically dispersed R&D when there is alignment between the countries of work experience and nationality of TMT members, on the one hand, and firms' R&D locations on the other. This influence is stronger for international work experience diversity than for nationality diversity, as the former provides more task-related knowledge to coordinate R&D activities and is less associated with the risk of social categorization. We find partial support for these notions in a panel analysis of the innovation performance of 165 leading MNCs based in Europe, Japan and the United States.

INTRODUCTION

An important feature of the modern MNC is its capacity to source and recombine technological knowledge from geographically dispersed knowledge hubs with specialized expertise (e.g. Lee, Choi, Ghauri, & Park, 2020; Belderbos, Leten & Suzuki, 2013; Chung & Yeaple, 2008; Mihalache, Jansen, Van Den Bosch & Volberda, 2012; Subramanian & Venkatraman, 2001; Penner-Hahn & Shaver, 2005; Blomkvist, Kappen & Zander, 2017). Geographic diversity of their R&D activities – which we define as operating R&D units in multiple countries - allows MNCs to directly engage with distant R&D networks in multiple geographies and thereby access their tacit and specialized local knowledge (e.g. Nuruzzaman, Gaur & Sambharya, 2019; Ahuja & Katila, 2004; Frost, 2001; Lahiri, 2010; Phene & Almeida, 2008; Belderbos, Lokshin & Sadowski, 2015; Leiponen & Helfat, 2011; Cantwell, 1995; Belderbos, Leten & Suzuki, 2017). Operating a dispersed network of R&D units is likely to elevate the degree of knowledge recombination and cross-fertilization within the firm, increasing the rate of innovation. A growing literature on the internationalization of R&D has suggested that such internationalization can potentially improve innovation performance and productivity but also comes with many challenges and coordination costs associated with increased complexities (e.g. Griffith, Harrison & Van Reenen, 2006; Todo & Shimizutani, 2008; Nieto & Rodriquez, 2011; Berry, 2014; Kafouros, Buckley & Clegg, 2012; Belderbos et al., 2015; Song and Shin, 2008; Belderbos, 2001). Research reveals that the effects of R&D internationalization on innovation performance depend on several contingencies such as effective cross-border collaboration and knowledge integration (Lahiri, 2008; Singh, 2008), and the absorptive capacity at home to assimilate and integrate knowledge from abroad (Penner-Hahn & Shaver, 2005).

In this paper, we argue that the characteristics of the Top Management Team (TMT) of the MNC are crucial in shaping such contingencies and the performance effects of international R&D. In the upper echelons literature (Hambrick & Mason, 1984; Neely, Lovelace, Cowen, & Hiller, 2020), it is well recognized that TMTs play a pivotal role in steering both the induced (top-down) and autonomous (bottom-up) strategic processes that shape a firm's innovation and strategic renewal capability, and, ultimately, its long-run performance (Burgelman, 1991). Similarly, the international and R&D management literature has emphasized that senior executives are key actors in influencing the nature of knowledge flows in MNCs due to the significant roles they play in coordinating and integrating global knowledge flows (Bouquet, Morrison & Birkinshaw, 2009; Foss & Pedersen, 2004; Nobel & Birkinshaw, 1998; Manev & Stevenson, 2001; DeMeyer, 1991). Such leadership is also essential to leverage resources in MNCs' corporate (R&D) networks across affiliates and countries (Menz, Sven & David, 2015; Boone, Lokshin, Guenter, & Belderbos, 2019). Evidence indeed suggests that TMT members are responsible for, and are often strongly involved in, the decision making with regard to the location of international R&D activities, the allocation of R&D projects and R&D budgets, and the organization of global R&D (Ivarsson et al., 2017; Chen, Hsu & Huang, 2010; von Zedtwitz & Gassmann, 2002; Thursby & Thursby, 2006; Michalache et al., 2012), using a combination of formal planning instruments, committees and task forces, and personal networks (Manolopoulus et al., 2011). For example, Ivarsson et al. (2017) documents the R&D coordination activities in the 17 largest Swedish MNCs. A large majority of firms work with global R&D committees involving TMT members (such as the Chief Technology Officer) who decide on the overall R&D budget as well as the budgets of the separate R&D units. These committees analyze and approve annual plans of the local units and prioritize between competing local initiatives, and take decisions on expatriates and key staffing of each unit (Ivarsson et al, 2017, p. 161). Moreover, these high-level committees decide on global R&D projects staffed with dedicated personnel, combining expertise from different units, in order to foster collaboration and knowledge complementarities. All this underscores the importance of studying which TMTs are better able to deal with the complexities associated with R&D internationalization and, therefore, to reap its innovation-performance potential. The role of TMT characteristics may thus be an important contingency factor, pivotal in shaping the performance consequences of firms' international R&D strategies.

This paper contributes to the literature by examining the role of TMTs, in particular the internationalization of TMTs, in enhancing the effectiveness of geographically dispersed R&D operations for innovation performance. We build on the upper echelons theory, which claims that firms' strategies are, at least in part, a reflection of the attributes of their TMTs (Hambrick & Mason, 1984; Finkelstein, Hambrick & Cannella, 2009; Lyon & Ferrier, 2002; Neely et al. 2020; Buyl, Boone, & Wade, 2019). Much research in this long tradition has indicated that diversity in the background and experience of executives increases the breadth of knowledge, information, and cognitive resources available to the TMT for making strategic decisions (Boone & Hendriks, 2009; Certo, Lester, Dalton & Dalton, 2006; Heavey & Simsek, 2013; Knight et al., 1999; Simons, Pelled & Smith, 1999), yet that diversity also introduce risks of conflicts and social categorization (Bunderson, Van der Vegt, Cantimur, & Rink, 2016; Harrison & Klein, 2007; van Knippenberg, De Dreu, & Homan, 2004; Richard et al. (2019). Boone, Lokshin, Guenter, & Belderbos (2019) observe that nationality diversity of TMTs is associated with a greater diversity of international knowledge sourcing leading to improved innovation outcomes, but only if the functioning of the TMT is not characterized by hierarchy and power distance.

In the present paper, we do not focus on TMTs as antecedents of internationalization decisions, but examine two international dimensions of diversity in TMTs that are expected to be particularly salient in effectively managing geographically dispersed R&D networks once they are in place:[1] the diversity in nationalities represented in the TMT and the diversity in the prior international work experience (IWE) of TMT members. Both these features of TMT composition may be pivotal since they are likely to be associated with a more open and creative decision-making (George & Chattopadhyay, 2009) based on a greater variety of international perspectives, and relevant knowledge of and connections with the overseas scientific, industrial, and regulatory institutions. Although both nationality and IWE diversity are indicative of TMT members' experience in, and knowledge about foreign countries, IWE captures more the extent to which an executive has hands-on, task-related, contemporaneous knowledge of particular institutional settings and markets, and has up-to-date local networks of informal social ties (Greve, Nielsen, & Ruigrok, 2009). Nationality, in contrast, includes deep-level imprinting of tacit norms and conventions specific to the country in which one is born and raised. Due to these differences, it is important to juxtapose the potential consequences of both forms of international diversity in TMTs simultaneously, as they are likely to have differential effects on the management of international R&D.

Our hypotheses build on earlier upper echelons research showing that the successful implementation of a firm's strategy depends on the extent to which the strategy's task requirements are aligned with the human capital, experience and personality of its managers (Greve, et al, 2009; Gupta & Govindarajan, 1984; Boone, De Brabander & van Witteloostuijn, 1996). We argue that the alignment or 'match' between the internationalization pattern of the TMT with the geographic pattern of R&D activities (countries that host the MNCs' R&D activities are also represented on the TMT) positively influences innovation performance. This is because such a match facilitates the orchestration of top-down and bottom-up processes that allows firms to reap the benefits of geographically dispersed R&D. It provides

[1] We address the role of TMT characteristics as antecedent of international R&D in the methods section.

TMTs with more knowledge and expertise to implement appropriate structures, processes and incentive systems that facilitate resource and knowledge sharing, and knowledge integration between dispersed R&D labs. In addition, the link with, and knowledge about local contexts facilitate the management of interfaces with middle and R&D lab managers as it allows top executives to “engage with impact” (Simsek, Heavey & Fox, 2018; Raes, Heijltjes, Glunk & Roe, 2011). We further expect that the hands-on, task-related knowledge and up-to-date local networks due to international work experience will be more important than the deep-level imprinting of tacit norms and conventions due to nationality, while the risk that diversity leads to conflicts and social categorization is also likely to be more limited in the case of international work experience. Empirically, we examine the relationships between innovation performance, geographically dispersed R&D, and TMT characteristics in a panel of 165 leading MNCs based in the US, the EU, and Japan.

Our study contributes to both the research stream on the internationalization of R&D and the literature on the role of upper echelons in firms’ strategic choices and outcomes. We contribute to the R&D internationalization literature through our focus on the crucial role of TMTs, which has until now been neglected. We contribute to the upper echelons tradition by responding to the calls in the literature (e.g. Narayanan, Zane & Kemmerer, 2011) for a greater focus on understanding how the characteristics of the TMT shape the implementation of firm strategy. Prior work has observed a positive relationship between TMT nationality diversity and firm performance (Nielsen & Nielsen, 2013), and a positive association between both TMTs’ nationality diversity and international work experience with strategic decision making on internationalization such as foreign market entry (Greve, et al, 2009; Nielsen & Nielsen, 2011; Reuber & Fischer, 1997; Daily, Certo & Dalton, 2000; Tihanji, Ellstrand, Daily & Dalton, 2000; Barkema & Shvyrkov, 2007; Kirca, Hult, Deligonul, Perry & Cavusgil, 2012; Fernandez & Sundaramurthy, 2020), and international knowledge sourcing activities

(Boone et al., 2019), but the role of the TMT in the management of international (R&D) operations is an important complementary perspective, the study of which enhances our insight. We examine this by juxtaposing two salient characteristics of TMT diversity - nationality and international work experience. In a departure from prior literature on TMT diversity, we argue that it is not TMT diversity per se that is salient for effective implementation, but a specific *pattern* in the diversities that allows for an alignment with the geographic pattern of R&D activities.

BACKGROUND AND HYPOTHESES

Unlike the increasingly globalized nature of MNCs' production activities, geographic diversity of R&D activities is a surprisingly less widespread, more recent phenomenon (Berry, 2014; Belderbos et al., 2013; Cantwell, 1989). This is despite the general awareness about the considerable technological and cost benefits that R&D internationalization can generate. Geographically diversified R&D activities can speed up innovation by helping firms access varied capabilities and specialized skills, often at a lower cost than in their home countries (e.g. Penner-Hahn & Shaver, 2005; Lahiri, 2010; Kedia & Mukherjee, 2009). Such a strategy also allows firms to learn about novel applications of their existing capabilities, in particular, as a response to the specific demands of the foreign markets (Regnér & Zander 2014; Kogut & Zander, 1992). Increasingly, foreign R&D units are mandated with the development of new technologies rather than merely adapting technologies to the particular circumstances of foreign markets (Awate, Larsen, & Mudambi, 2015; Kuemmerle, 1997; Ivarsson et al., 2017; Blomkvist et al., 2017; Belderbos et al. 2015; Dunning & Narula, 1995; Cantwell & Mudambi, 2005; Cantwell, 1995). A geographically dispersed R&D strategy enriches the recombinatory potential of firms' knowledge repertoire, in the sense that it allows them to expand the heterogeneity of their knowledge resources that facilitates the creation of new knowledge combinations and innovation (Nuruzzaman et al, 2019; Regnér & Zander 2014).

The relatively limited adoption of international R&D strategies is related to, on the one hand, the challenges associated with designing and effectively implementing such complex R&D configurations (e.g. Regnér & Zander 2014; DeMeyer & Mishima, 1989; Von Zedtwitz & Gassman, 2002; Brockhoff & Schmaul, 1996) and, on the other hand, firms' 'home bias' in R&D due to their historic embeddedness in innovation systems in their home countries (Belderbos et al., 2013; Narula, 2012). Geographic diversity of R&D activities can dampen the effectiveness of a firm's innovation process because having to deal with multiple cultures increases the complexity of interfaces among the R&D units and between the R&D units and the MNC headquarters, increasing the difficulties of coordination and monitoring (Baier et al. 2015; Castellani et al. 2017). Hence, the potential benefits of a geographically dispersed R&D strategy have to be weighed against the costs of and the complexities associated with managing and coordinating R&D operations in multiple locations. Top management teams can play a key role in addressing these issues and facilitating the effective implementation of international R&D strategies. Below we draw on the upper echelon and international business literatures to elaborate how TMT member diversity in terms of nationality and international work experiences can enhance the effectiveness of international R&D configurations.

An effective contribution to a firm's technological innovation by foreign R&D units will require these units to tap into location specific expertise and resources and hence to generate distinctive knowledge elements in the MNC's knowledge pool (Lisak, Erez, Sui & Lee, 2016; Phene & Almeida, 2008; Berry, 2014; Belderbos, Jacob, Lokshin, 2018). Support from headquarters is essential, as R&D units' roles and activities are a function of the resources allocated, the communication with headquarters, and the exchange of expertise and knowledge between them (Cantwell & Mudambi, 2005). To their disadvantage, overseas R&D units historically often suffer from a legitimacy deficit due to concerns of managers at the parent firm about their reliability as sources of new technology developments (Hewitt, 1980; Szulanski 1996; Gupta & Govindarajan, 2000; Berry 2014). Parent firms also may have fears about a loss of control that can result from potential spillovers of sensitive technologies to competitors (Alcacer & Zhao, 2012; Di Minin & Bianchi, 2011). These could mean an insufficient allocation of resources to foreign R&D units and underutilization of their research outcomes in the technology development processes within firms. In addition, the presence of multiple R&D units combined with a limited involvement of the parent firm and TMT in the coordination and integration of R&D programs can result in the creation of redundant knowledge due to the duplication of activities.

Even if foreign R&D units have gained legitimacy and credibility in the eyes of the parent firm, the overall contribution of a geographically dispersed R&D network could be reduced by the complexities associated with coordinating the activities of the various units and integrating the knowledge they create. This is because technology development within an internationally dispersed R&D network is an iterative, interactive process wherein headquarters and foreign R&D units need to regularly engage and collaborate with each other to develop a shared understanding of the problem(s) at hand (e.g. Weick, Sutcliffe & Obstfeld, 2005; Baier et al. 2015). With their different communication and decision-making styles and disparate vocabularies and perspectives (Ferraris, Bogers & Bresciani, 2020; Parkhe, 1993), a geographically diverse R&D program can hamper shared understandings (Ceci & Prencipe, 2013; van Knippenberg & Schippers, 2007) and the execution of a firm's R&D efforts. Under these circumstances, we contend, top executives with connections to the countries in which R&D units are located can serve as the bridges between these units and the headquarters, mitigating the coordination and integration complexities, elevating their status, and ultimately allowing for a greater contribution of the units to the firm's innovative activities.

The upper echelon literature underlines that senior executives play a significant role in implementing these complex strategies, given especially the ambiguities that such strategies create in organizations (e.g. Narayanan, Zane & Kemmerer, 2011; Heavey & Simsek, 2017; Boone, De Brabander & van Witteloostuijn, 1996; Heavey & Simsek, 2013; Mihalache et al., 2012; Talke, Salomo & Kock, 2011; Boone et al., 2019). A major challenge for firms pursuing a globally oriented R&D strategy is a lack of detailed information of an area's technological strengths and its suitability to meet the firms' knowledge demands. This may give managers of local (R&D) units room to engage primarily in their own local initiatives (Wooldridge, Schmidt & Floyd, 2008) that may not be aligned with the firm's overall innovation goals, resulting in limited integration of the innovation efforts at the broader firm level. Senior managers of the firm who have personal and professional links to a foreign country could be the key to resolving these challenges by serving as bridges between the local R&D unit and the parent firm, guiding the development of local initiatives that complement the firm's overall R&D activities (Heavey & Simsek, 2013; Talke, Salomo & Rost, 2010). Knowledge about local contexts facilitate the management of interfaces between R&D lab managers and other middle managers, hence allowing top executives to "engage with impact" (Simsek, Heavey & Fox, 2018; Raes, Heijltjes, Glunk & Roe, 2011). Top managers with local connections may, furthermore, act as advocates of the foreign units in the headquarters, elevating their profile within the corporation and removing roadblocks that hinder their development. Assistance from senior executives who are familiar with a foreign location's business environment, language, culture, and economic and political systems also contributes to local units adopting best local practices and establishing task related routines and processes (Watson, Kumar & Michaelsen, 1993; Hambrick et al., 1996) that ensure the efficient transfer and absorption of local tacit knowledge within the firm (Manev & Stevenson, 2001; Athanassiou & Nigh, 2000).

TMT members routinely exchange their knowledge of foreign markets and hence form a shared understanding about the parent firm's inter-connected operations in multiple countries (Mihalache et al, 2012; Athanassiou & Nigh, 2000). Members of the TMT are directly involved in global R&D committees that leave them with the means to influence the design, priorities, budget allocation, and collaborations in global R&D (Ivarsson et al., 2017, p. 161). Given the close involvement of TMT in the international R&D strategy of a firm, a TMT member with the contextual knowledge of a certain country due to nationality or country experience may be appropriately positioned to ensure that the R&D unit located in that country is well plugged in the firm's global R&D network such that frictions and complexities across multiple interfaces involving that unit in the firms' R&D network is minimized and its cross-border collaborations are enhanced, ultimately enhancing the effectiveness of the firm's R&D internationalization strategy (e.g. Frost and Zhou, 2005). Cross-unit and cross-border collaboration of R&D personnel is common in MNCs (Alcacer and Zhao, 2012; Nandkumar and Shrikant, 2017) also to allow for a greater control by headquarter of knowledge creation and to guard against knowledge outflows.

The above arguments suggest that TMTs have several means to steer global R&D and that they are more likely to take informed decisions that allow for effective resource allocation and collaborations within the firm's R&D network if the countries of the R&D units are represented in the TMT. If members have a match of the geographic pattern of TMT member nationality and international work experience with that of international R&D operations, ensuring that foreign R&D locations are 'represented' on the TMT, they can more effectively implement a geographically-dispersed R&D program. The management of dispersed international R&D operations benefits from the specific knowledge of executives about the locations they are familiar with. Hence, the value of a diverse TMT derives not from diversity per se but from the match between the geographic pattern of a firms' R&D network and the countries represented on the TMT in terms of nationality and work experience. We therefore propose the following hypothesis:

Hypothesis 1: *TMT international diversity that matches the geography of the MNC's international R&D activities is positively associated with the innovation performance of MNCs.*

Nationality and work experience diversities enhance decision making in their own, often, distinct ways. Nationality diversity provides TMTs with the knowledge of diverse institutions, norms, and environments (e.g. Lisak et al, 2016). Executives are imprinted with the collectively held tacit beliefs and values of the countries in which they were raised and have internalized the formal institutions that govern transactions. Such a deep-level imprinting is expected to have a longstanding effect on executive decision making and behavior (Hambrick et al., 1998). International work experience affects the cognition and behavior of executives by exposing them to the unique economic and political systems, business models, market trends, and formal and informal networks of foreign countries. Yet we argue that international work experience of TMT members is likely to be more salient than nationality in bringing performance benefits of international R&D

First, recent work experience in a certain location represents task-related knowledge specific to that location, with TMT members possessing a fine-grained understanding of the affiliates' R&D capabilities as well as knowledge of, and connections with local institutions and R&D networks. In general, international work experience implies inter-firm international employee mobility – at the upper echelon level -, which has been found to be conducive to inter-firm knowledge flow and innovation (Liu, et al., 2010). Recent work experience in a country will have allowed the TMT member to build up and shape a social network with key actors in the firms' affiliate (Manev & Stevenson, 2001). This social capital is critical for the TMT member to perform her role of coordinating and integrating global knowledge flows (Heavey & Simsek, 2017; Bouquet et al., 2009; Foss & Pedersen, 2004; Meyer et al. 2011). The international intra-firm networks and coordination capabilities are vital for executives to perform their role as boundary spanners (e.g. Ancona & Caldwell, 1988) helping foreign R&D units to improve linkages with the R&D network of the parent firm, claim required R&D resources, and integrate and coordinate on R&D activities across units.

In contrast, association with a foreign location stemming from nationality may entail less of these qualities, as executives do not typically possess recent task-related knowledge of the foreign affiliate and have not been able to build and shape social networks that facilitate knowledge flows and improved coordination. Hence, the implementation of international R&D strategies is likely to be more enhanced, and innovation consequences stronger, if IWE diversity, compared with nationality diversity, is more aligned with the geography of the MNC's R&D locations.

Second, when dispersion of international R&D across multiple units in various countries requires greater diversity of the TMT, such diversity also introduce risks of conflicts and social categorization (Bunderson, Van der Vegt, Cantimur, & Rink, 2016; Harrison & Klein, 2007; van Knippenberg et al., 2004; Richard et al., 2019), but we argue that such risks are substantially lower if international diversity concerns international work experience in comparison with nationality. Social categorization theory suggests that diversity may actually hamper exchange and communication with dissimilar team members because people identify more with similar team members and may have stereotypes and prejudices about dissimilar team members (van Knippenberg & Schippers, 2007; Williams & O'Reilly, 1998). Such social categorization processes spur negative in-group –outgroup dynamics in multinational teams and provoke interpersonal conflict, competition, and dysfunctional political behavior (van Knippenberg & Schippers, 2007). This may reduce the potential benefits of TMT international diversity for the performance of international R&D by hampering agreement on budget allocation and collaborative R&D teams. Such dysfunctional ingroup-outgroup team dynamics are more likely to emerge if social categorization occurs along the lines of a salient deep-level characteristics that shape an individual's imprinted values and identity such as nationality. International work experience in contrast, may cover various countries and a multitude of geographically-based work experiences that do not demarcate sharp social categories among members of the TMT. Hence, diversity in international work experience is much less likely to be associated with stereotype-based social categorization processes that might hamper effective TMT processes.

The arguments above suggests the following hypothesis:

Hypothesis 2: *The match between TMT international work experience and the geography of R&D activities has a stronger positive association with innovation performance than the match between TMT nationality and the geography of R&D activities.*

METHODS, DATA AND SAMPLE

We test our hypotheses on longitudinal data spanning the years 1998 to 2007 on publicly listed MNCs operating across a variety of industries including pharmaceuticals, chemicals, plastics, machine tools, electronics, transport equipment, and paper. The sample firms were among the top 5-10 largest players in the European market in their respective industries in terms of sales and had patent applications in the observation period, but could be headquartered outside of Europe. The focus on European market leaders stems from the use of secondary data gathered to examine the relationship between technology and market leadership in Europe for the European Commission (Commission of the European Communities, 2010). Among the 250 identified leading firms, 165 publicly listed firms applied for at least one patent during the period. Despite the focus on European market leadership, the firms are headquartered in a broad range of (20) countries, including firms from the US and Japan in addition to European firms.

We initially used annual reports to identify top executives employed in the focal firms during the sample period. We subsequently used the BoardEx database to extract information concerning these top executives. The BoardEx database contains information on demographic and education characteristics, employment history, and current and past executive ranks of individuals who are current or past board members or senior executives in publicly quoted companies. In total, we gathered information on over 3000 executives employed by the sample companies at some point during the sample period.

We retrieved and consolidated data on patent applications yearly, drawing on patent applications at the European Patent Office by the firms as contained in the PATSTAT database. We rely on patents to measure innovation performance and to construct the geographic diversity in R&D (see below). The use of EPO data follows from the focus on the European market players - as firms that play a major role in the European market are most likely to apply for patents in Europe, and has other advantages related to the more elaborate examination practice at the European Patent Office (Van Pottelsberghe, 2007). The use of EPO data then provides the benefit of using one common benchmark for patent applications and hence inventor identification and innovation performance. Yearly firm-level patent ownership at the consolidated level was determined based on annual reports listing firms' global consolidated subsidiaries and information on acquisitions and divestments drawn from the Zephyr and SDC databases. Finally, we obtained data on the R&D expenditures, number of employees and geographic segmentation of sales from the Datastream and Worldscope databases, complemented with information from the annual reports.

Focal Variables

The dependent variable is the citation-weighted count of patents of the firm at the consolidated level, taking the patent application date as the first indication of new inventions (e.g. Arundel & Kabla, 1998). Patents offer a rich source of information for studies on innovation and have extensive use as an indicator of innovation performance (Phene & Almeida, 2008; Ahuja & Katila, 2004). The main advantage of patent data is consistency and objectiveness, since European Patent Office examiners validate patents based on requirements of novelty and utility of use. Drawbacks are that patent propensities vary across industries and firms; and patented inventions differ in their technical and economic value. To address the heterogeneity in patent value, we weigh each patent with the citations the patent receives from later patents (forward citations) in a four-year window. Empirical evidence has demonstrated significant correlation between forward citations of a patent and the value of the underlying invention (e.g. Chiou et al., 2016; Hall et al., 2005). Furthermore, our analysis controls for firm-specific differences in the propensity to patent and (with time dummies) for changes in macroeconomic conditions that may affect innovation efforts and outcomes.

The focal independent variable *geographic diversity of R&D* is the Blau index of the firm's distribution of R&D activities across countries. Given the absence of systematic data on the locations of firms' R&D laboratories and the evolution in these over time, we follow prior research on international R&D (e.g. Belderbos et al., 2013; Kafouros, Buckley & Clegg, 2012; Lahiri, 2010; Ahuja & Katila, 2004) by utilizing information from patent data on the location of firms' patent inventors. We use the location of inventors rather than the location of the patent assignees, as the former has been shown to be a much more accurate reflection of the locations where inventions took place (e.g. Deyle & Grupp, 2005). The distribution of patents across inventor locations has been shown to be closely correlated with the distribution of R&D (Patel & Pavitt, 1990) and the identification of R&D activities at the country level quite accurate if a threshold of a number of patents is used (Belderbos, Leten & Suzuki

2013).[2] We follow this approach and conservatively consider a country to host an R&D unit of a firm if the firm's inventors file for a minimum of 4 patents in that location over a period of 3 years.[3] We base our measure on patent applications, since this is a more encompassing indicator of the presence of foreign R&D activities than patent grants, as the latter exclude R&D efforts and inventions that do not result in grants. Since patents may be associated with inventors who are based in more than one country, we use a fractional count approach whereby for each patent a location is assigned a value equal to the proportion of inventors based there. We construct the geographic diversity of R&D as the Blau index of the distribution of patents over countries with R&D units during a three-year period.

We defined membership of *top management team*s as individuals on the executive board or individuals with at least the rank of Vice President (Chairman, Vice Chairman, Chief Executive Officer, Chief Financial Officer, Chief Technology Officer, Chief Operating Officer, Executive Vice President, and Senior Vice President). This operationalization is consistent with extant studies on top management teams (e.g. Michel & Hambrick, 1992). *Nationality* is the country of birth of each top executive and *international work experience* (IWE) captures work experience that top managers obtained outside the home country of the focal firm in the past 5 years. We retrieved information on the former and the latter from the Boardex database. We construct *TMT international diversity* using the Blau index of

[2] We note that, given the novelty requirement for patents, the patent based measure of R&D location may give more weight to research activities in comparison with (local) development and adaptation activities that may be less likely to lead to patentable results.

[3] This threshold provides a reasonable assurance that we are measuring real R&D activity and that the patent data do not pick up the odd cases of inventors outside the firm who collaborated on a patent. The three-year period helps to identify R&D establishments that do not apply for patents every year. Applying different criteria (2 and 6 patent thresholds) gives similar results.

heterogeneity (Blau, 1977): $B=1-\sum(s_i)^2$ wheres$_i$ s_i is the proportion of the TMT with the *i*-th nationality or country in which international experience was obtained. The variable indicating the match between *TMT international diversity* on the one hand, and geographic diversity of R&D on the other hand, is constructed as the number of countries in which the firm conducts R&D activities that are also represented in TMTs through members' nationality or IWE. Hypothesis 1 suggests a positive coefficient for this match variables in the innovation performance model.

To test hypothesis 2, we construct two variables indicating separately the match between *TMT nationality* and R&D locations and the match between *TMT international work experience* and R&D locations. In order to separate these two dimensions of TMT international diversity, we construct the TMT nationality match from members' nationality not covered by international work experience, and the TMT IWE match from work experience not covered by managers' nationalities. Hypothesis 2 suggests that the effect of the *TMT IWE match* is greater than that of *TMT nationality match*. The match variables constructed in this way allow us to examine to what extent an implementation effect concerning the geographic diversity of R&D is due to the specific country profile match.

Control variables

We control for several time-variant TMT-related characteristics. In addition to controlling for a general effect of TMT *international diversity*, we include *TMT functional diversity*, which captures the degree to which top managers differ in terms of their functional expertise. TMT compositional diversity with respect to functional background of executives has been shown to influence firm's strategic decision making (e.g. Wiersema & Bantel, 1992) and to enhance decision quality and organizational performance (Boone & Hendriks, 2009; Cannella, Park & Lee, 2008). Following prior research on functional diversity (Talke et al., 2010; Talke et al., 2011) we identified eight different functional categories: finance and administration, sales and marketing, operations, human resources, legal, IT, research & development, and classified each executive in one of the groups depending on his or her dominant specialization. We then calculated the Blau index of functional diversity. *Tenure diversity* was constructed following prior work (Wiersema & Bantel, 1992; Barkema & Shvyrkov, 2007) as the coefficient of variation (standard deviation divided by the mean) of tenure across TMT members. Tenure was calculated as the time span between the focal year and the year the top executive joined the TMT. *TMT size* is measured as the number of TMT members, and *TMT age* is the average age of TMT members. Finally, to control for structural vertical interdependency within a TMT we include a dummy equal one (else zero) if an additional hierarchical level of a chief operating officer (COO) is present in a team (Hambrick, Humphrey & Gupta, 2015).[4]

At the firm level, the analysis takes into account several time-variant characteristics of firms that may affect innovation performance. We include the logarithmically transformed value of consolidated *R&D expenditures* to account for variations in inputs into the innovation process. The variable is taken at the consolidated level and reflect R&D expenditures that include those of target firms in case of M&As. In addition, the variable *patents/R&D* (patent productivity, measured as the stock of past patent applications divided by R&D expenditures) controls for time varying firm-level differences in the propensity to patent. In case of M&As, the variable includes the patents of the target firm(s) acquired during the year.

Geographic diversity of sales and *product diversity of sales* are Blau indices of geographic and product segmentation of firm's sales, respectively, and control for firms'

[4] We ran additional analyses to check whether the models are sensitive to the alternative ways to operationalize control variables: we included the standard deviation in place of the coefficient of variation to measure tenure diversity (Sorensen, 2002), a composite measure introduced by Hambrick, Humphrey & Gupta (2015) in place of dummy for COO to control for social stratification within TMTs. Our results are not sensitive to these alternatives

general internationalization and diversification patterns that prior research has identified to correlate with TMT diversity and TMT work experience (e.g. Tihanyi, Ellstrand, Daily & Dalton, 2000; Carpenter & Fredrickson, 2001; Lee & Park, 2008). To isolate the influence of external knowledge sourcing strategies that may complement firms' international R&D activities abroad (Boone et al., 2019) we include the variable *Geographic diversity of technology-based strategic alliances, corporate venture capital investments and technology based M&As,* constructed as the Blau index of concentration of the countries of origin of M&A, CVC targets and alliance partners. We used Thomson's SDC Platinum database as well as the MERIT-CATI database to retrieve information on technology alliance activities, Thomson's Financials VentureXpert database for information on corporate venturing, and SDC and the Zephyr database to retrieve information on technology oriented M&As (M&As with target firms active in patenting or in technology alliances). Finally, *firm size* (the logarithm of firm employees) is included to account for remaining general size effects on innovation.

Methods

Our estimation sample consists of panel data on 165 firms comprising 1224 firm-year observations. The use of lags to construct focal independent variables means that we estimate our models for the period 2000 – 2007. The core dependent variable, innovation performance, is a count variable, which necessitates the use of panel count models. The LR test commonly used to verify the assumption of the Poisson model that the expected variance of the dependent variable equals its mean strongly rejects this assumption ($p < .001$). As a result, we employ negative binomial models that directly accommodate over-dispersion. Because the Hausman (1978) specification test suggests that the fixed effects negative binomial model is to be preferred (Chi2= 99.94; p-value < .001), we employ the fixed effects model. We lag the right-hand side variables by one year to allow for a natural ordering of strategy and outcome, as prior research has suggested a lag between R&D and innovation performance (Griliches, 1986). The literature has found that in strategy performance models, endogeneity may occur because unobserved firm-specific characteristics may drive both the strategy decision and the performance outcomes of this strategy (Bascle, 2008; Semadeni, Withers, and Certo, 2014; Shaver, 1998). This creates a correlation between the focal variables of interest and the error term, generating bias in the estimates. Since we estimate fixed effect negative binomial models, the analysis already controls for any time invariant unobserved firm heterogeneity, such that any unobserved heterogeneity as a source of potential endogeneity has to be time-variant. A test for the nature of unobserved heterogeneity does not suggest that this is time variant in our models, perhaps because we estimate particularly rich innovation models controlling for the time variant propensity to patent and a range of changing TMT characteristics.[5] Nevertheless, we aimed to rule out the possibility that an omitted factor such as for instance 'TMT managerial effort to improve innovation outcomes' may correlate with R&D geographic diversity, the match, and innovation performance but is not sufficiently captured by the set of time-variant controls in the model.

We address this potential endogeneity concern by employing a two-stage instrumental variable model in which we use the predicted values of *geographic diversity of R&D* from a first equation in the innovation performance equation of interest. More formally, our two-stage model can be summarized by the following equations:

$$\mathrm{GEO\_DIV\_R\&D}_{\mathrm{it}-1} = \mathrm{TMT\_INT}_{\mathrm{it}-1} + \mathrm{W}_{\mathrm{it}-1} + Z_i + \omega_{\mathrm{it}-1} \qquad (1)$$

[5] We tested whether unobserved heterogeneity is time-variant or time-invariant by applying a Hausman type of procedure on the difference between fixed-effects and first-difference estimators, suggested by Bartolucci et al. (2015). This test did not reject the null hypothesis that unobserved heterogeneity is time-invariant: chi2 (15) = 18.41 (p= 0.2418).

$$PAT_{it} = \widehat{GEO\_DIV}\_R\&D_{it-1} + TMT\_INT_{it-1} + Match_{it-1} + W_{it-1} + f_i + T + \varepsilon_{it} \quad (2)$$

Where W_i is the vector of time-variant control variables and Z_i is the vector containing instruments or exclusion restrictions and other time-invariant variables such as year and industry dummies, f_i are firm fixed effects, T is a vector of time dumies, and ω and ε are idiosyncratic error terms.

Following prior research suggesting that TMT diversity can influence firm internationalization (e.g. Boone et al., 2019; Nielsen & Nielsen, 2011; Reuber & Fischer, 1997; Daily, Certo & Dalton, 2000; Tihanji, Ellstrand, Daily & Dalton, 2000; Barkema & Shvyrkov, 2007; Kirca, Hult, Deligonul, Perry & Cavusgil, 2012), the model allows for an effect of the international diversity of the TMT (TMT_INT_i) in influencing the geographic diversity of R&D, while such diversity is also a control variable in the innovation model. Hence, in this conceptualization, TMT international diversity is allowed to affect innovation performance both directly, and indirectly if it fosters the geographic diversity of R&D. This ensures correct estimates for our focal variables: the alignment of TMT international diversity characteristics and foreign R&D locations.

The dependent variable in the first stage model, *geographic diversity of R&D*, only takes values in the interval (0,1). We employ a fractional regression with robust standard errors, which is appropriate for this type of dependent variable (e.g. Wooldridge, 2010). The first-stage model includes pseudo fixed effects: the pre-sample count of the number of countries in which the firm conducts R&D activities (i.e. Z_i). This variable, which is highly statistically significant, serves as exclusion restriction and allows identification of the two-stage model. It is a variable with a strong influence on current R&D geographic diversity but that is unaffected by the potential source of endogeneity: potential time-variant unobserved characteristics of the firm and TMT. Pioneering work on international R&D and firm performance (Griffith et al. 2006) has used a comparable method to examine exogenous influences of foreign R&D. The pseudo-fixed effects approach to control for unobserved heterogeneity was first suggested by Blundell, Griffith, and Van Reenen (1999) and is attractive in that it does not require strict exogeneity of the explanatory variables and provides consistent estimates. The results of the first stage regression are reported in the appendix. As the predicted value of the geographic diversity of R&D is stochastic in nature, we report bootstrapped standard errors in the innovation (second stage) model (Wooldridge, 2002, p. 378; Preacher and Hayes, 2008).

RESULTS

Table 1 lists the means and standard deviations of the variables and their correlation coefficients. On average, the Blau index of R&D dispersion is 0.40 (firms in our sample have R&D units in 4.2 countries on average), similar to the Blau index of international diversity of TMT members (0.45). The match between foreign counties represented on the TMT and R&D locations is relatively limited: on average 1.4. IWE diversity is responsible for a larger part of this match (1.08 versus 0.33 countries on average) but the two dimensions of the match exhibit substantial variation across observations. We ascertained that the average variance inflation factor is 1.76, with the highest observed value 2.7, suggesting no substantive multicollinearity concerns... There is a relatively high correlation between the control variables firm R&D and firm size, and between the focal variables TMT nationality- and TMT IWE-based match variables (a correlation coefficient of 0.59). We therefore also test for the effects of the TMT nationality match and TMT IWE match separately.

INSERT TABLE 1

Table 2 presents the estimation results. Model 1 presents a baseline specification that examines the drivers of innovation performance, including only the set of control variables. Results show that firm size and R&D have significant and positive associations with innovation. This also holds for firms' geographic diversity and product diversity of sales. Among the TMT-related control variables, TMT international diversity has a positive association with innovation performance, but the significance of this effect disappears once the predicted geographic diversity of R&D is included (models 2-6). A stronger hierarchy, as indicated by the presence of a chief operating officer, is negatively associated with firm innovation.

INSERT TABLE 2

When we introduce the predicted values of geographic diversity of R&D into the analysis (model 2) the coefficient is positive and significant. Models 3 through 6 add the match variables between geographic diversity of R&D on the one hand, and TMT international diversity (model 3), TMT nationality diversity (model 4) and TMT IWE diversity (model 5) on the other, to test the predictions of Hypotheses 1 and 2. In model 3, the overall TMT international diversity match variable has a significantly positive coefficient, in support of Hypothesis 1. In model 4 the coefficient on the match between geographic diversity of R&D and TMT nationality diversity is negative but not significant, while in model 5 the match between TMT IWE diversity and the geographic diversity of R&D is positive and significant. These observations remain unchanged in the model with all variables included (model 6). A Wald test rejects equality between the two match variables in model 6, with a χ^2 test statistic of 4.74 (p= 0.029). These results provide clear support for Hypothesis 2.

The estimated coefficients can be interpreted as semi-elasticities: the proportional increase in innovation performance due to a 1 unit increase in the independent variable. This implies that an increase in the match variable for TMT IWE diversity by one standard deviation increases innovation performance by about 7 percent. A standard deviation increase in the geographic diversity of R&D adds about 6 percent to innovation performance.

Supplementary analysis

We considered a number of alternative specifications of our model.[6] We examined to what extent an effective implementation of a geographically diverse R&D strategy could also be due to TMT IWE and TMT nationality diversity as such, rather than the specific country match between TMT international diversity and foreign R&D. The interaction effects between the TMT nationality diversity and TMT IWE diversity and geographic diversity of R&D were not significant, and negative and significant, respectively. The results suggest that additional performance gains cannot be reaped by increasing R&D and TMT diversity simultaneously, but only by matching locations of innovation activities to the backgrounds and experiences of the TMT member. Ignoring this match while increasing diversity of both R&D and TMTs may even lead to reduced innovation performance.

When we do not define the IWE and nationality match as the unique contributions of these two dimensions of TMT international diversity towards matching R&D locations, but include in the measures countries that are represented in TMTs through members' nationality already covered by international work experience and vice versa, results remained robust. Findings were also unchanged when we replaced the control variable TMT international diversity by its two dimensions, TMT IWE diversity and TMT nationality diversity. Both IWE and nationality diversity had a significant impact on R&D international diversity in stage 1, but consistent with the results in Table 2, the TMT international diversity variables had no significant association with innovation once the match variables were included in the models.

Our results were also robust to the use of additional instruments in the first stage model (Lewbel, 2012), to the omission of the first stage from the model, to the use of different threshold values of patents invented per country to determine the presence of R&D facilities, to inclusion of an (insignificant) square term of R&D geographic diversity, and to omitting

[6] The full results of the tests are reported in a separate appendix for the review process.

co-patents from the identification of R&D locations. We did not observe significant differences in the coefficients of the focal variable if we allowed coefficients to differ between firms with above and below the median patent propensity, respectively. If we estimate the model on those (1010) observations of firms for which all or the majority of R&D locations were already determined at the start of our sample period, further mitigating endogeneity concerns due to unobserved TMT characteristics, comparable results were observed for the focal match variables.

Finally, we sought further evidence corroborating an important mechanism that we argue is underlying the hypothesized relationships. If the alignment of internationalization of TMT members and R&D units can foster innovation performance by stipulating, encouraging and facilitating effective inter-unit collaboration, such inter-unit collaboration should be more vivid in cases where there is such an alignment. We examined all patents of the sample firms in the observation period and retrieved information on inventor teams (co-inventors), and in particular information on the location (unit) of co-inventors. We then examined the correlation between the match variable for the 1224 observations in the analysis and the number and share of patents with cross-country co-inventor teams involving multiple identified R&D units of the firms. We identified 71985 patents overall, of which 27 percent involved cross-country cross-unit collaboration. The correlation coefficients between the three match variables and the cross-unit co-inventions were highly significant ($P<0.000$) at .65 (overall international TMT match), .60 (international work experience match) and .49 (nationality match). Similarly, the correlation coefficients between the match variables and the share of cross-country co-invented patents in total foreign invented patents of foreign laboratories were .39, .35, and .25, respectively ($P<0.000$). These patterns clearly confirm that the alignment of R&D locations and the international profile of TMT members is associated with more (intensive) collaboration between R&D units across countries, and particularly so for work experience alignment - consistent with our theory and empirical results.

DISCUSSION AND CONCLUSION

Examining the relationship between innovation performance, geographic diversity of R&D, and TMT nationality diversity and international work experience diversity in a panel of 165 leading MNCs based in the US, the EU, and Japan, we found support for the notion that such international diversity of TMTs is associated with higher innovation performance through their influence in facilitating the effectiveness of geographically diverse R&D strategies. TMT diversity related to international work experience strengthens the performance effects of a geographically diversified R&D strategy, but only when there is alignment between the country work experiences of TMT members and firms' R&D locations. This pattern was not found for TMT nationality diversity.

Our findings are of particular importance in light of the fact that, despite its many perceived benefits, R&D internationalization is not fully embraced by many MNCs and empirical evidence on its performance consequences remains mixed. The international experience represented in the TMT is instrumental in ensuring a fuller realization of the potential benefits of geographically dispersed R&D operations. International work experience provides the essential task-related knowledge, social networks, and contextual understanding necessary to coordinate and integrate the knowledge flows deriving from R&D activities in diverse locations. International diversity through work experience is also less likely to be associated with the risk of conflict and social categorization, in comparison with international diversity through nationalities with the accompanying deeply imprinted social norms. Overall, our findings support the observations by Richard et al. (2019), that TMT task related faultiness in TMTs do not hamper strategic change and may facilitate knowledge sharing. At the same time, we confirm that not all international experience or TMT members matters for performance (Fernandez & Sundaramurthy, 2020), but that only experience that matches with the foreign R&D environment is relevant to improve the performance effects of geographically dispersed R&D.

Although we predicted weaker effects of a TMT nationality-R&D location match due to a potential counteracting influence of nationality-induced social categorization and the importance of recent knowledge of, and networks with local R&D operations and the local environment, we still expected that having R&D locations represented on the TMT in terms of the nationality of TMT members would also help coordination and integration efforts and improve the legitimacy of the foreign R&D units. A possible explanation for the absence of such advantages could be that national identity may also impart in executives a certain degree of self-interest to divert R&D budgets to their home countries, resulting in in-group bargaining rather than objective articulations of opportunities offered by different locations (Mihalache et al., 2012; Harrison & Klein, 2007). Such partisan tensions within TMT may hamper the effective implementation of R&D internationalization strategies, offsetting the positive effects that nationals can impart through granting autonomy and resources, and promoting innovation and entrepreneurship in these R&D units (Asakawa, 2001). Hence,

Our study contributes to the R&D internationalization literature through our focus on the crucial role of TMTs' international diversity in the management of geographically dispersed R&D operations. The role of the 'match' between geographic diversity and TMT international work experience provides new insights to the literature on the contingencies under which international R&D affects innovation outcomes. Alignment in IWE diversity can and does facilitate effective cross-border collaboration and (knowledge) integration in the MNC (Singh, 2008; Lahiri, 2010; Berry, 2014; Liu et al., 2010; Meyer et al., 2011; Frost and Zhou, 2005) and may enhance the information processing capabilities of the TMT (Mihalache et al., 2012) for leading and coordinating the firm's specific international R&D configuration.

Our findings thus advances prior work by identifying critical TMT-level contingencies on the effectiveness of firms' international R&D strategy.

Our study also contributes to the upper echelons tradition by extending research on TMT nationality and IWE diversity (e.g. Nielsen & Nielsen, 2013; Boone et al., 2019) and highlighting an important strategy - geographic diversity of R&D - through which TMT diversity can enhance innovation performance. Prior studies have stressed the general importance of TMTs in shaping firm-level R&D and innovation (Boone et al., 2019; Chen et al., 2010; Daellenbach et al., 1999; Lyon & Ferrier, 2012; Talke et al., 2010), but have either not considered the role of international TMT diversity, or its relationship with the performance of international R&D of MNCs. Our study follows earlier work in highlighting the importance of examining multiple dimensions of TMT diversity simultaneously (e.g. Boone & Hendriks, 2009; Nielsen & Nielsen, 2011).The precise alignment or 'match' of TMT diversity, in particular IWE diversity, with the relevant dimensions of firm strategy is critical for realizing the full potential of this strategy. In this respect, we provide further evidence of the importance of matching managerial characteristics with strategies, which earlier research has explored at the business-unit level of MNCs (e.g. Gupta & Govindarajan, 1984) or in terms of CEO characteristic (Thams et al., 2020).

We recognize that although our study utilizes a rich empirical setting of multinational firms based in multiple countries, our focus on relatively large and leading firms may make our findings less relevant for smaller MNCs. Our study is also unable to make causal claims and we interpreted the empirical results as associations. We minimize concerns related to endogeneity by using an instrumental variable approach, by including firm (pseudo) fixed effects, by controlling for the MNC's patent application propensity, and by performing several robustness tests. Nevertheless, a fruitful avenue for further research would be to integrate in more detail the antecedents of TMT nationality and IWE diversity and their match with R&D locations in MNCs (Boone et al., 2019;Van Veen, Sahib, & Aangeenbrug, 2014).

Another limitation of our research is that it focused on the role of TMTs at MNCs' corporate headquarters, while current trends in global MNC organization suggest a greater dispersion of headquarter responsibilities involving divisional and regional headquarters (e.g. Nell et al., 2017). These dispersed headquarters often act as a bridge between corporate headquarters and local affiliates in seeking entrepreneurial opportunities and coordinating knowledge transfer within the MNC (e.g. Belderbos, Du & Goerzen 2017). Future research should examine the influence of such headquarter dispersion and the characteristics of management teams at this level on MNCs' global R&D allocation and the effectiveness of a geographically dispersed R&D organization. A related issue that warrants exploration in future research is the characteristics of subsidiary managers and the nature of their interactions with TMT members (Wooldridge et al., 2008). For instance, executives at some subsidiaries may have previously worked closely with TMT member(s). This raises the question whether such prior connections of subsidiary managers substitute for the facilitating role of TMT international work experience diversity.

The relatively aggregate level of analysis in our study also suggests follow-up research on the specific mechanisms through which the implementation of an international R&D strategy influences innovation performance. Complementary research may focus on utilizing case studies (e.g. Delios, 2017) to uncover such processes. Our analysis already confirmed a strong correlation between the TMT international experience match and intra-firm collaboration in the innovation process (e.g. Singh, 2008; Frost & Zhou, 2005; Alcacer &Zhao, 2012), and this relationship certainly warrants further attention. We encourage future research to shed further light on the associations between TMT profiles, knowledge integration and innovation performance.

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Table 1. Correlations and descriptive statistics

	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Citation-weighted patents	293.90	540.0																
2. Geo diversity R&D (predicted)	0.40	0.32	-0.04															
3. Firm size (in 1000), in logs	3.76	1.35	0.42	-0.12														
4. Patents/R&D	0.42	1.85	-0.01	0.05	-0.10													
5. R&D	5.34	2.19	0.52	-0.13	0.69	-0.24												
6. Geo diversity sales	0.62	0.16	0.02	-0.01	0.04	0.00	0.06											
7. Prod diversity sales	0.55	0.24	0.12	0.05	0.10	0.01	0.07	0.09										
8. Geo diversity - SA MA CV	0.62	0.36	-0.05	0.10	-0.15	0.06	-0.20	0.09	0.00									
9. TMT size	11.40	10.58	0.32	-0.01	0.31	-0.05	0.42	0.03	0.14	-0.15								
10. TMT diversity – Tenure	0.68	0.27	-0.07	0.03	0.15	-0.03	0.08	0.00	-0.06	-0.04	0.23							
11. TMT average age	51.11	4.35	0.11	-0.04	0.11	-0.02	0.09	0.04	-0.02	0.02	-0.18	-0.14						
12. Chief operating officer	0.22	0.42	-0.06	0.02	0.01	-0.04	0.03	0.04	0.05	0.00	0.17	-0.04	-0.10					
13. TMT diversity – FB	0.62	0.19	0.03	-0.02	0.20	-0.03	0.21	0.02	-0.03	-0.04	0.33	0.17	-0.17	0.11				
14. TMT diversity – International	0.45	0.23	0.04	0.13	0.17	0.00	0.06	0.19	-0.03	0.01	-0.04	0.13	-0.02	0.04	0.06			
15. Match TMT International & R&D location	1.42	1.82	0.52	0.21	0.36	-0.03	0.53	0.10	0.19	-0.09	0.48	0.09	-0.03	0.02	0.20	0.33		
16. Match TMT Nationality & R&D location	0.33	0.71	0.38	0.16	0.18	-0.01	0.34	0.06	0.14	-0.06	0.40	0.05	-0.05	-0.01	0.14	0.20	0.72	
17. Match TMT IWE & R&D location	1.08	1.44	0.52	0.18	0.39	-0.03	0.54	0.11	0.20	-0.08	0.49	0.09	-0.02	0.03	0.16	0.31	0.95	0.59

Table 2. TMT international diversity, the geographic diversity of R&D activities, and innovation performance

	(1) innovation	(2) innovation	(3) innovation	(4) innovation	(5) innovation	(6) innovation
Firm size	0.116**	0.149***	0.145***	0.149***	0.148***	0.148***
	(0.050)	(0.050)	(0.050)	(0.050)	(0.051)	(0.051)
Patents/R&D	0.039	0.032	0.032	0.032	0.033	0.033
	(0.085)	(0.084)	(0.083)	(0.084)	(0.084)	(0.084)
R&D	0.169***	0.207***	0.187***	0.207***	0.191***	0.192***
	(0.055)	(0.057)	(0.060)	(0.058)	(0.060)	(0.060)
Geo diversity sales t-1 (HH)	0.417***	0.715***	0.663***	0.715***	0.674***	0.674***
	(0.149)	(0.200)	(0.198)	(0.199)	(0.200)	(0.200)
Prod diversity sales t-1 (HH)	0.260*	0.089	0.062	0.089	0.076	0.076
	(0.134)	(0.146)	(0.141)	(0.147)	(0.143)	(0.144)
Geo diversity - SA MA CV	0.059	-0.082	-0.053	-0.082	-0.060	-0.060
	(0.052)	(0.073)	(0.074)	(0.073)	(0.074)	(0.073)
TMT size	-0.006	-0.009**	-0.011***	-0.009**	-0.011***	-0.011**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
TMT diversity – Tenure	-0.101	-0.150**	-0.102	-0.150**	-0.117	-0.117
	(0.073)	(0.073)	(0.075)	(0.073)	(0.075)	(0.075)
TMT average age	0.002	-0.001	-0.001	-0.001	-0.001	-0.001
	(0.007)	(0.007)	(0.007)	(0.006)	(0.007)	(0.007)
Chief operating officer	-0.136*	-0.117	-0.105	-0.117	-0.106	-0.106
	(0.074)	(0.072)	(0.070)	(0.073)	(0.072)	(0.072)
TMT diversity – FB	-0.116	-0.128	-0.191	-0.128	-0.169	-0.170
	(0.203)	(0.188)	(0.189)	(0.188)	(0.188)	(0.187)
TMT diversity – International	0.680***	0.211	0.126	0.211	0.170	0.172
	(0.171)	(0.216)	(0.206)	(0.217)	(0.213)	(0.214)
Geo diversity R&D (predicted)		0.874***	0.715**	0.874***	0.743**	0.745**
		(0.339)	(0.343)	(0.336)	(0.350)	(0.348)
Match TMT Int. and R&D location			0.051***			
			(0.015)			
Match TMT Nat and R&D location				-0.000		-0.004
				(0.022)		(0.021)
Match TMT IWE and R&D location					0.044***	0.044***
					(0.015)	(0.015)
Log-likelihood	-4861.158	-4854.235	-4847.123	-4854.235	-4850.242	-4850.232
Wald	210.07***	288.120***	316.625***	296.649***	315.950***	365.886***
χ^2 of improved model fit		13.85***	14.22***	0.00	7.99***	0.02

Notes: Results of fixed effects negative binomial models. The geographic diversity of R&D is predicted in a first stage model presented in the appendix; bootstrapped standard errors are applied. * p<0.1, ** p<0.05, *** p<0.01. Standard errors in parentheses. All models are estimated on a sample of 1224 observations for 165 firms and include a constant and 7 time dummies. The χ^2 test statistic is the likelihood-ratio test comparing the focal model with the more parsimonious model.

Appendix: First stage analysis of the determinants of R&D international diversity

	Geo div. R&D
Pre-sample mean	0.048***
	(0.016)
Firm size	-0.033
	(0.029)
Patents/R&D	0.005
	(0.015)
R&D	-0.061***
	(0.023)
Geo diversity sales t-1 (HH)	-0.409**
	(0.164)
Prod diversity sales t-1 (HH)	0.185
	(0.115)
Geo diversity - SA MA CV	0.162**
	(0.072)
TMT size	0.004**
	(0.002)
TMT diversity – Tenure	0.072
	(0.100)
TMT average age	0.001
	(0.006)
Chief operating officer	-0.011
	(0.060)
TMT diversity – FB	-0.050
	(0.154)
TMT diversity – international	0.389***
	(0.115)
Log-likelihood	-790.060
Wald	1317.084***

Note: Results of fractional response model. Robust standard errors in parentheses, * p<0.1, ** p<0.05, *** p<0.01. All models are estimated on a sample of 1224 observations for 165 firms and include a constant and 7 time dummies and 23 industry dummies.

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