Organizing for continuous technology acquisition: The role of R&D geographic dispersion

DESIGNING R&D STRUCTURE TO SUSTAIN OPEN INNOVATION: THE IMPACT OF R&D GEOGRAPHIC DISPERSION ON TECHNOLOGY ACQUISITION

Abstract: Acquiring external technologies has been identified as an important strategy to improve firms' innovative performance. Furthermore, the previous literature has revealed how organizing R&D in a geographically dispersed manner may affect firms' inclination towards the use of open innovation strategies. Thereby, the present paper investigates the relationship between the geographic decentralization of R&D activities and the propensity of firms to acquire technological solutions. In addition, we also investigate how this relationship is moderated by the firms' technological diversification. We tested our hypotheses on longitudinal data of 303 biotechnology firms that acquired, at least, one USPTO patented technology over the period 1982-2012. Results reveal that the geographic dispersion of R&D activities has an inverted U-shaped effect on the firms' propensity to acquire technologies. Additionally, findings show that this relationship is negatively moderated by the technological diversification of the firms.

Keywords: Technology acquisition; R&D geographic dispersion; technological diversification; open innovation; R&D decentralization

1. Introduction

Until the last years of the 20th century, companies used to manage their internal innovation processes by avoiding the exchange of knowledge and ideas with different organizations, accordingly to the closed innovation paradigm (Chesbrough, 2003). However, the increasing competitive pressure, geographic dispersion of knowledge, and reduction of products' life cycles characterizing the competitive environment of the last decades started to erode the advantages of the closed innovation paradigm, to the extent that firms cannot longer rely exclusively on their in-house R&D processes and resources (Enkel et al., 2009). Thereby, in order to timely and effectively innovate, they are called to integrate internally and externally developed knowledge in their R&D processes, consistently with the emerging principia of the open innovation paradigm (Chesbrough, 2003).

A number of strategies can be used by companies to feed their internal R&D activities with external knowledge, such as the establishment of R&D alliances, mergers and acquisitions, and participation in markets for technologies (MFTs) (Arora et al., 2001; Chesbrough, 2003). In particular, MFTs are increasingly attracting the attention of academics and managers as a mean to sustain firms' open strategies (Arora and Gambardella, 2010), since they expand firms' opportunities to acquire technical solutions. This is crucial to tap into the latest technological advancements (Tsai et al., 2011) and reduce R&D costs and time to market, which ultimately lead to better financial performance (Gambardella et al., 2007; Kafouros & Forsans, 2012; Walter, 2012). Consequently, many organizations nowadays actively acquire technologies and use them to set the basis for their future innovative activities, as in the case of the acquisition of the common rail technology by the Bosch Group (Messeni Petruzzelli, 2015).

Organizational structure is considered as an important antecedent for implementing open innovation strategies, as technology acquisition, which has indeed given rise to new configurations in the organizational R&D structure (Bianchi et al., 2011; Chesbrough, 2003; Huizingh, 2011; Naqshbandi & Kaur, 2011). However, the literature has yet to develop full comprehension of the organizational mechanisms (e.g., specialization, decentralization, and formalization) that create a positive environment sustaining and enhancing such an innovative approach (Huizingh, 2011; Ihl et al., 2012). Furthermore, most of the research on technology acquisition has so far investigated the motivations leading firms to acquire technological solutions (e.g., Tidd & Trewhella, 1997), the characteristics of technology owners and seekers (e.g., Arora & Gambardella, 2010), and the performance implications of a technology acquisition strategy (e.g., Tsai et al., 2011; Walter, 2012). Notwithstanding, explaining if and how the organizational structure affect the firms' propensity to acquire technologies still represents an underdeveloped area of research that may offer relevant theoretical and practical contributions. Specifically, among the diverse organizing mechanisms identified in the literature, R&D decentralization has recently attracted the interest of organization and management scholars, with particular emphasis on the "global decentralization" (Gassmann & von Zedtwitz, 2003; Kochen & Deutsch, 1973; Leiponen & Helfat, 2011). Indeed, a large number of companies had decentralized their R&D centers (e.g., Hewlett-Packard, IBM, Rockwell, ABB, Intel, and Philips) revealing an increasing geographic distribution of R&D activities, in the attempt to improve their innovative capabilities (DeSanctis et al., 2002; Gassmann & von Zedtwitz, 2003; Singh, 2008).

Accordingly, taking into account the central role assumed by the spatial perspective in open innovation studies (Gassmann et al., 2010), the first objective of this paper is to analyze the relationship between organizing geographically distributed R&D activities and the firms' propensity to acquire technological solutions. Additionally, this relationship is likely to be contingent upon the diversification of companies' technological competencies. In fact, recent research has shown that the influence of R&D organization structure on firms' innovative performance is affected by their level of technological diversification, especially in globally decentralized companies (Lahiri, 2010). Therefore, as the second objective of this study, we examine the moderating effect of technological diversification on the relationship between R&D geographic dispersion and the firms' propensity to acquire technologies to innovate.

We develop hypotheses and test them adopting a panel data regression approach based on longitudinal data (1982-2012) on 303 biotechnology companies that have acquired, at least, one patented technology, as indicated in the United States Patent and Trademark Office (USPTO) patents assignment database. Results reveal that the degree of geographic distribution of R&D activities exerts an inverted U-shaped effect on the extent to which firms acquire new technologies, and that this relationship is negatively moderated by technological diversification.

The remainder of the paper is structured as follows. In the next section, we discuss the theoretical arguments and develop the hypotheses. Afterwards, we present the research methodology and outline the results. Finally, the last section concludes the paper by discussing main implications, limitations, and future research directions.

2. Theory and hypotheses

Acquiring external technologies is deemed as a relevant open innovation strategy, which allows firms to reduce time and costs of the innovative activities (Gambardella et al., 2007; Tsai et al., 2011). The adoption of centralized or decentralized R&D structures has been proved to impact this external sourcing strategy (Leiponen & Helfat, 2011). Specifically, among the distinct decentralization mechanisms, scant attention has so far received the global decentralization of R&D activities (Gassmann & von Zedtwitz, 2003; Leiponen & Helfat, 2011). Previous studies have demonstrated the impact of the geographic configuration of R&D on firms' innovative performance (Leiponen & Helfat, 2011), as well as on the quality (Lahiri, 2010; Singh, 2008) and novelty of their innovative outcomes (Tzabbar & Vestal, 2015). However, scant attention has been dedicated to how it affects the firms' openness. In particular, this issue is becoming more important as firms are increasingly revisiting the organization of their R&D activities in order to implement open innovation strategies, as the case of technology acquisition (Gassmann et al., 2010). Thereby, with this study we attempt to contribute to the extant literature, by examining how the geographic distribution of R&D activities affects firms' propensity to acquire technologies. In the following, we will use the term centralized R&D to indicate R&D structures characterized by low geographic dispersion, conversely decentralized R&D points out to R&D structures characterized by high geographic dispersion.

Furthermore, the past research showed that the effects of R&D geographic dispersion on search activities are tightly related with the diversity of the company's technological expertise (e.g., Lahiri, 2010). For instance, companies characterized by a high degree of technological diversification may decide to avoid duplication costs of research resources, as it may occur in the case of decentralized R&D structures, hence limiting the spectrum of external search of each R&D center to specific technological areas (Lahiri, 2010; Pisano, 1990) and influencing the overall innovation process. The above arguments resemble findings of previous studies revealing how firms' organizational structure and R&D technology strategy are strongly intertwined (Cassiman & Valentini, 2009; Lin & Chang, 2015; Sampson, 2007). Accordingly, in the following, we also discuss how the firms' technological diversification moderates the relationship between R&D geographic dispersion and the propensity of technology acquisition.

2.1. R&D geographic dispersion and technology acquisition propensity

Previous studies pointed out that the geographic dispersion of R&D activities exerts both positive and negative effects on the performance and strategies of innovative companies (Asakawa, 2001; Singh, 2008). Indeed, on the one hand, interactions within the organization are more frequent and explicit in companies adopting a centralized R&D structure, thus favoring the development of trust, attitudinal similarity, and shared context (Harrison et al., 1998; Tzabbar & Vestal, 2015). These characteristics, in turn, make coordination and communication activities more effective, by reducing the risks of faultiness (Polzer et al., 2006), conflicts (Harrison et al., 1998) and social loafing (Stark et al., 2007) arising from geographic and cultural distances between R&D members. In fact, high geographical and cultural distances may create tensions between dispersed R&D members working on the same innovative projects, as reflected in the inability to manage external knowledge among the diverse R&D locations (Asakawa, 2001), which is however needed to make the adoption of open innovation strategies more effective. Thus, since companies with a centralized R&D structure can better manage and internally share information, acquisition and exploitation of external technical knowledge tend to be more successful (Lahiri, 2010), hence incentivizing the use of open strategies. Moreover, necessities and technological problems that researchers may encounter in centralized firms are also better understood, discussed, and conveyed to the management (von Zedtwitz & Gassmann, 2002). Therefore, the more effective information-processing and coordination processes may push R&D managers to find technical solutions to those issues also recurring to the external environment, hence supporting the positive attitude of the company towards the acquisition of externally developed technologies. Finally, companies with a strongly decentralized R&D structure are deemed to search less widely and develop innovations having a narrower span of applications, often limited to a given geographic area (Leiponen & Helfat, 2011). Thereby, they may lack the interest and the independence needed to acquire potentially valuable technologies that do not provide a straightforward solution to on-going local-specific issues (Arora et al., 2014), hence reducing their willingness to acquire technical solutions. In line with this reasoning, it seems that the higher the decentralization of R&D, the less the firms' propensity to acquire external technologies.

Nevertheless, it is worth noting that technical knowledge often resides in various geographic regions (Doz & Wilson, 2013). Thereby, organizing R&D in one or few geographical areas does not allow companies to timely scout and access external valuable technical solutions (Lahiri, 2010; Phene et al., 2006; Tzabbar & Vestal, 2015). In turn, this reduces the possibilities to acquire technologies before competitors and gain market advantages, hence making technology acquisition strategy less than ideal. Moreover, if firms deploy R&D centers where external technical knowledge resides, they are in a better position to recognize its potential value and understand its underlying rationale (Sole & Edmondson, 2002), thus facilitating its acquisition and subsequent exploitation in internal R&D activities (Gassmann & von Zedtwitz, 2003; Tyre & Hippel, 1997). Organizing R&D in a distributed manner also creates chances to undergo multicultural experiences. These experiences, while diminishing coordination and communication advantages gained by R&D centralization (Asakawa, 2001), expose companies to new problem-solving techniques and different sources of information, hence favoring the development of new and more complex cognitive schemas (Perry-Smith & Shalley, 2014). These improve the firms' capabilities to identify new technological opportunities using external technical knowledge (Phene et al., 2006), as well as to cross-fertilize and uniquely recombine the external knowledge with the internal one to innovate (Perry-Smith & Shalley, 2014; Tzabbar & Vestal, 2015; Savino et al., Forthcoming). This consequently generates an increasing interest in acquiring external knowledge by firms with a decentralized R&D structure. Furthermore, despite the ease of interactions in centralized R&D departments, previous research showed that sharing the same context and information sources may lead to cognitive myopia, create barriers to knowledge acquisition (e.g., not-invented-here syndrome - NIH), and increase firms' commitment to the status quo (e.g., Katz & Allen, 1982; Natalicchio et al., 2014; Tidd & Trewhella, 1997; Tzabbar & Vestal, 2015), hence reducing the willingness to search for externally developed solutions. Similarly, people in the same location, at some point, lose interest in exchanging information and experiences, feel to be all similar, and develop shared and redundant mental models (Mortensen, 2014; O'Leary & Mortensen, 2010). Contrarily, by dispersing R&D activities, companies get used to make their boundaries more fluid and become more open minded for knowledge exchange (Blomstermo et al., 2004; Fletcher & Harris, 2012). Thereby, attitudes limiting the external knowledge acquisition, such as the NIH syndrome, are lessened.

Therefore, considering both the benefits and drawbacks of both R&D centralization and decentralization, it is likely that there exists a moderate level of R&D geographic dispersion that maximizes firms' propensity to acquire technologies. Stated more formally:

Hypothesis 1: The relationship between R&D decentralization and the extent of firms' propensity to acquire technologies increases and then decreases, hence taking an inverted U-shaped form as the reliance on geographically distributed R&D activities grows.

2.2. Technological diversification and R&D geographic dispersion

A company that pursues a technological diversification strategy is likely to limit the advantages of R&D decentralization. In fact, as the technological diversification grows, concurrently with R&D geographic dispersion, each R&D facility tends to specialize in one or few research areas (Lahiri, 2010). Indeed, companies are often not able to cope with the costs associated with the replication and diffusion of the various technological areas covered by their R&D activities among diverse R&D locations (Lahiri, 2010), thus focusing on a narrow set of local-specific innovation objectives. As a consequence of this specialization phenomenon, mental attitudes avoiding external technology acquisition (e.g., NIH syndrome) are not overcome, since fewer chances and less interest in sharing and exchanging information between the geographically distributed R&D facilities exist (Mortensen, 2014). Moreover, the reduction of interactions between the R&D centers, caused by increasing costs of widening both technological competencies and R&D decentralization (Lahiri, 2010), also limits the possibilities that R&D members engage in multicultural experiences, hence reducing the development of more complex cognitive schemas and new problem-solving approaches (Perry-Smith & Shalley, 2014). This means that inventors will rely upon less developed recombinant capabilities to cross-fertilize firms' internal technical knowledge with external one. This diminishes the perceived value of external technologies (Lane et al., 2006) and so the propensity to acquire them. Eventually, the growth of technological diversification may reduce the advantages of decentralized R&D structure in being exposed to acquisition opportunities and negatively impact on the attitude of the company towards external technology sourcing.

Finally, conducting R&D activities across disparate technological domains comes with the increasing probability that companies incur in problems as over-diversification. Notably, being involved in technologically diversified research activities may lead to information overload and hinder the firms' capabilities to screen and select valuable ideas (Koput, 1997; Leten et al., 2007). Thereby, even though a company decentralizes its R&D activities where related technical knowledge resides, the inability to identify potentially relevant technologies, as a consequence of the wide technological diversification, might put firms in a position to disregard the geographically dispersed technical knowledge (Singh, 2008). Therefore, technological diversification combined with R&D decentralization may lessen the propensity to acquire technological solutions. The arguments above discussed lead us to formulate the following hypothesis:

Hypothesis 2: Firm's technological diversification negatively moderates the linear relationship between R&D decentralization and the extent of firm's propensity to acquire technologies.

3. Methods

3.1. Industry Setting

The biotechnology industry was used to test our hypotheses. The biotechnology industry was born in 1974, with the filing of the Cohen and Boyer's patent for the recombinant DNA technique. Some years later, Boyer co-founded Genentech, one of the first biotechnology companies, which developed the first human synthetic insulin; this became in 1982 the first biotechnology drug approved by the U.S. Food and Drug Administration (FDA) for human use. In the last decades, the biotechnology industry has massively grown and recent data report that more than 23 thousand firms are active in 2014, accounting for an industry R&D spending of more than 42 billion of U.S. dollars (OECD, 2015). The biotechnology industry was deemed as a suitable setting for our research due to several reasons. First, knowledge is highly regarded in this industry and it is a source of distinctive competitive advantage for firms (McMillan et al., 2000; Messeni Petruzzelli et al., 2012), accordingly biotechnology firms reveal a high patenting propensity, aiming at protecting the outputs of their innovative processes (Phene et al., 2006). Second, in the biotechnology industry there is a high tendency to commercialize patent rights among companies (Arora et al., 2001; Zucker et al., 2002). Finally, the knowledge components available for innovative activities in the biotechnology sector are widely diversified and tend to reside and specialize in different regional clusters (Gittelman, 2007). Therefore, biotechnology firms rely on interdisciplinary competencies to innovate (Phene et al., 2006), and are also embedded in geographically dispersed research communities, with the aim to tap into the diverse knowledge needed to sustain their innovative activities (Gittelman, 2007). According to the above arguments, we are confident about the suitability of our setting to test the hypotheses.

3.2. Data

In order to build the sample on which we based our analysis, first, we extracted the full list of biotechnology firms available in the 2012 Bio Scan® database, which also includes relevant organizational information for each company, such as size, year of incorporation, subject areas, and ownership status. Second, we queried the USPTO patents assignment database to obtain all the transactions involving the assignment of a patent interest[1] to one of the firms included in our list (i.e., the acquired patents), concerning the period 1982-2012 (observation years). Specifically, we started our data collection from 1982, since it represents a fundamental milestone in the evolution of the biotechnology industry, corresponding to the year in which the FDA approved for the first time the use of genetically engineered drugs for human use. Moreover, we focused on the USPTO since the United States represent the largest market for biotechnology firms (Phene et al., 2006). Third, we removed from the initial sample of firms those that did not acquire the ownership rights of any patent in the period of interest. Hence, the final sample includes 303 biotechnology firms. Finally, for each firm in our sample, we also collected all the patents in the USPTO patent database that it successfully filed for till 2012. For these and for the acquired patents, we obtained detailed bibliographic data from the USPTO patent database. The resulting model includes 6,323 firm-year observations with a mean number of observations per company of 20.9.

3.3. Variables

Dependent Variable. The sourcing of patents owned by other organizations has been considered as a valid mean to assess whether a company has adopted a technology acquisition strategy (Capon & Glazer, 1987; Tsai et al., 2007, 2008). Accordingly, consistently with our research question, we measured the propensity to acquire technologies as the number of patents that a firm acquired in each year of the observation period (1982-2012) (*Acquired*).

Independent Variable. For each patent developed by the firms in our sample, we calculated the degree of geographical dispersion of the inventive team as one minus the Herfindahl concentration index of the countries where related inventors are located, as indicated in the patent document (e.g., Lahiri, 2010; Singh, 2008). Then, the R&D geographic dispersion of the firm (*GeoDispersion*) is a lagged variable measuring the mean value of the dispersion of the inventive team of all the patents filed by a given firm in the period between *t-1* and *t-5*, respect to the observation year *t*. Accordingly, we captured for the R&D geographical dispersion in the five years that precede the

[1] Indicating the transfer of part or entire patent ownership interest (see Section 301 of the USPTO Manual of Patent Examining Procedure).

patent rights acquisition in order to account for the locations where only active inventors operate (Paruchuri et al., 2006).

Moderating Variable. To measure firms' technological diversification, we identified the three-digit US classes assigned to all the patents filed by the firms in our sample in the five years preceding the observation year *t*. Therefore, we operationalized the technological diversification of the firm (*TechDiversification*) as one minus the Herfindahl concentration index of the patent classes in which a focal firm patented technologies in the period between *t-1* and *t-5* (Lin & Chang, 2015). In this case, the five-year window was chosen in order to account for technology depreciation and firms' forgetting issues (Katila, 2002; Nooteboom et al., 2007).

Control Variables. In our analysis we also included variables to control for firm and acquired patent characteristics. Concerning firm characteristics, we controlled for the firm size (*FirmSize*), measured as the natural logarithm of the number of employees. We added a dummy variable controlling for the ownership of the firm (*Public*), assuming value one if the firm is publicly traded, and zero otherwise; while another dummy accounting for the firm subsidiary status (*Subsidiary*) was included, taking the value one when the company is a subsidiary, zero otherwise. Additionally, we controlled for the number of different subject areas in which the firm operates (*SubjectAreas*), and whether it exclusively operates in the biotechnology sector (*DedicatedBio*), through the use of a dummy variable. The firm age (*FirmAge*) was also taken into account, counting the number of years elapsed between the establishment of the firm and the observation year. Finally, we controlled for the firm's technological capital (*TechCapital*), as a proxy for its expertise and capability to innovate. Specifically, *TechCapital* was computed as the number of patents that the firm filed for during the five years preceding a given observation year *t* (Nooteboom et al., 2007). Concerning patent characteristics, first, we included a variable evaluating the breakthrough potential of the acquired patents (*Breakthrough*), by calculating the mean number of forward citations they received at the time of the acquisition (Ahuja & Lampert, 2001). Second, we controlled for the mean age of the acquired patents in year *t* (Patent*Age*) and the mean number of patent claims (*Claims*). Finally, to take into account technological novelty, we calculated the mean number of backward citations (*Novelty*) (Ahuja & Lampert, 2001).

3.4. Model specification

We adopt a random-effects negative binomial regression model to assess the firms' propensity to acquire technologies in a given year *t*. A random-effects model is preferred to a fixed-effects one, since it allows specifying and analyzing the error caused by serial correlation in our panel data (Derfus et al., 2008). Indeed, differences across firms may have some influences on our dependent variable, therefore making fixed-effects as less than ideal (Greene, 2008). In addition, in the fixed-effects model time invariant variables are absorbed by the intercept and not accounted for, even if they may have an impact on our dependent variable (Wooldridge, 2012). Moreover, the negative binomial regression model is preferred for two main reasons. First, we have a non-negative count dependent variable that is not normally distributed, hence violating a key assumption of generalized least squares regression analysis (Wooldridge, 2012). Second, our dependent variable is overdispersed (see Table 1), thus we use a negative binomial model, since it corrects for overdispersion by calculating an additional parameter in the regression, differently from a Poisson regression approach (Frome et al., 1973).

4. Results

Table 1 shows descriptive statistics and pairwise correlations, revealing values below the 0.70 threshold, hence avoiding multicollinearity concerns (Cohen et al., 2013).

<Insert Table 1 about here>

Table 2 presents results of the random-effects negative binomial regression. Different models are considered. Model 1 includes the control variables only. Models 2 serves as partial model and includes the effects of *GeoDispersion* as linear and quadratic terms. Finally, Model 3 is the full model used to test our hypotheses.

<Insert Table 2 about here>

Per Model 1, the propensity to acquire patents is positively influenced by the number of subject areas covered by the firms (β=0.012, $p<0.05$), the high breakthrough potential of the acquired technologies (β=0.019, $p<0.001$), their age (β=0.137, $p<0.001$), novel nature (β=0.069, $p<0.001$), and number of claims (β=0.012, $p<0.001$).

Per Model 3, the two hypotheses result to be supported. Indeed, the linear term of *GeoDispersion* is positive and significant (β=6.143, $p<0.001$), whereas its squared term is negative and significant (β=-6.939, $p<0.01$), hence supporting Hypothesis 1. Moreover, consistently with Hypothesis 2, the interaction term between the linear term of *GeoDispersion* and *TechDiversification* is negative and significant (β=-6.142, p<0.001). Specifically, we tested Hypothesis 2 only considering the interaction of *TechDiversification* with the linear term of *GeoDispersion*, since we do not expect the inverted U-shaped form to change at any level of *TechDiversification* (Aiken & West, 1991).

Furthermore, we performed some robustness analyses to ensure the reliability of our results. First, we incorporated the interaction of the squared term of *GeoDispersion* with the moderating variable (*TechDiversification*). This interaction is found to be not statistically significant, indicating that technological diversification mostly influences the linear trajectory of the *GeoDispersion*, as hypothesized. Second, since few extreme observations may explain the inverted U-shaped relation predicted in the first hypothesis, we manage outliers by winsorizing at the 2% (1% from bottom and 1% from the top) and 4% (2% from bottom and 2% from the top) (Wilcox, 2012). Our initial results remain consistent in both cases. Third, we used the count number of diverse countries where inventors reside in order to measure R&D geographic dispersion. In this case Hypothesis 2 is fully supported, whereas Hypothesis 1 is partially supported, since the coefficients are consistent with the hypothesised effects, but show a lower statistical significance.

5. Discussion and conclusion

This study investigates the influence of firms' R&D decentralization on their propensity to acquire technologies and the moderating effect of firms' technological diversification on this relationship. Results based on a unique longitudinal database including information on 303 biotechnology companies in the period 1982-2012 show that R&D decentralization has an inverted U-shaped effect on the propensity to acquire technologies. We ascribe this effect to theories suggesting that both centralizing and decentralizing R&D activities in diverse countries provides advantages and disadvantages to technology acquisition, thus supporting the idea that there is a moderate level of R&D decentralization that maximizes the propensity to acquire technological solutions. Indeed, on the one hand, R&D centralization favors the creation of more effective information-processing and coordination processes, which allow companies to more easily find solutions to technical problems also recurring to the external environment (Asakawa, 2001; von Zedtwitz & Gassmann, 2002). On the other hand, R&D decentralization supports companies in more easily scouting and understanding geographically dispersed technical knowledge (Phene et al., 2006), improves recombinant capabilities (Mortensen, 2014; Savino et al., 2015), and favors the creation of fluid organizational boundaries (Fletcher & Harris, 2012). Furthermore, we reveal that the advantages of dispersing R&D activities respect to the firms' propensity towards technology acquisition are hindered when firms are technologically diversified. In fact, in order to overcome redundant R&D

activities among the diverse R&D locations, each research center tends to become more specialized (Lahiri, 2010), hence reducing its openness and the possibilities that R&D members engage in multicultural experiences. Moreover, technological diversification may lead to problems as information overload (Leten et al., 2007), which likely puts firms in a position to disregard geographically dispersed technical knowledge, since they are less able to perceive its benefits to innovate (Singh, 2008).

These results let us identify relevant theoretical and practical implications. First, from a theoretical perspective, this paper contributes to the literature on MFTs (Arora et al., 2001), by revealing the role of R&D geographic dispersion on the firms' propensity to acquire technologies. Indeed, despite technology acquisition has posed new challenges regarding the organizational structures that sustain such an innovation approach (Arora et al., 2014; Huizingh, 2011), scant attention has been posed on the role of firms' decentralization mechanisms. Particularly, recognizing that global decentralization is becoming a common practice among many companies (Gassmann & von Zedtwitz, 2003), we contribute to the extant literature by investigating its impact on firms' propensity to acquire technologies, instead of on internal innovative outcomes (e.g., Singh, 2008). Second, our results also contribute to the ambidexterity literature, by shedding further light on the intertwined relationship between decentralizing R&D and diversify firms' technological competencies, which is an issue largely disregarded in previous studies (Lahiri, 2010). Notably, both can be considered as explorative approaches to innovation, letting firms acquire new valuable ideas. However, their relation seems to be substitutive rather than complementary. Thereby, these findings also contribute to highlight the importance of balancing exploration and exploitation across domains (e.g., Lavie & Rosenkopf, 2006; Messeni Petruzzelli, 2014), due to reduced organizational impediments and cognitive constraints.

From a practical perspective, our results are meaningful in that they reveal the double-edged sword effect of R&D decentralization in sustaining firms' propensity to acquire technologies. Indeed, our findings suggest managers that a moderate level of geographic dispersion is required to favor technology acquisition. Specifically, companies need to identify the optimal level of R&D decentralization that allows them to sustain technology acquisition by accessing to geographically distant knowledge and engaging in multicultural experiences, while avoiding to lose the benefits also deriving from R&D centralization, as coordination and information-processing. Furthermore, we revealed that being technologically diversified and geographically dispersed might reduce the propensity to acquire technologies. It is therefore important for managers to critically analyze the organizational structure of the firms and their technology strategy at the same time, so that reduction of inflow of external technical solutions is prevented. This finding reveals how designing organizational structure and technology strategy to sustain technology acquisition cannot be separate tasks. Furthermore, we suggest decentralized companies to define proper organizational mechanisms that allow them to reduce the costs of redundancy when the technological knowledge base becomes broad. In this way they may avoid that the dispersed R&D locations stay focused on the local-specific objectives only, which may threaten the openness of their innovation processes.

As with most studies, this work has some limitations that can however provide new interesting line of inquiries. First, besides the biotechnology sector, other industries may be investigated to generalize our results. Second, additional decentralization mechanisms and organizational features (e.g., structural form) may be taken into account to further delve into the relationship between the organization of R&D and technology acquisition. Third, environmental factors (e.g., intellectual property regime and country policies) represent other important contingencies on this relationship that may be considered in further studies. Finally, we mainly consider patent transactions. Other sources of information may be used to analyze additional data.

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Tables

Table 1. Descriptive statistics and pairwise correlations

	N	Min	Max	Mean	S.D.	1	2	3	4	5
1-Acquired	6323	0	636	.95	12.206	1				
2-GeoDispersion	6323	0	.776	.077	.131	.027*	1			
3-TechDiversification	6323	0	.987	.435	.366	.055**	.292**	1		
4-FirmSize	6323	0	5.188	2.572	1.202	.032*	-.022	.380**	1	
5-Ownership	6323	0	1	.560	.496	-.001	.039**	.106**	.100**	1
6-Subsidiary	6323	0	1	.190	.388	-.002	-.021	-.009	.041**	-.326**
7-SubjectAreas	6323	1	43	8.980	8.324	.002	-.032**	.209**	.487**	.025*
8-DedicatedBio	6323	0	1	.420	.494	-.005	.090**	-.033**	-.241**	.072**
9-FirmAge	6323	0	210	30.190	38.754	.030*	-.048**	.356**	.648**	.097**
10- Technological capital	6323	0	10,316	94.140	459.304	.005	-.014	.258**	.334**	.129**
11-Breakthrough	6323	0	170	.652	4.546	.087**	.054**	.067**	.061**	.037**
12-Novelty	6323	0	19	.176	1.28	.205**	.054**	.083**	.059**	.006
13-PatentAge	6323	0	98	2.199	7.258	.159**	.101**	.126**	.044**	-.013
14-Claims	6323	0	254	1.834	9.686	.099**	.067**	.080**	.007	-.007

*p<0.05; **p<0.01

Table 1. Descriptive statistics and pairwise correlations (continued)

	6	7	8	9	10	11	12	13	14
6-Subsidiary	1								
7-SubjectAreas	,051**	1							
8-DedicatedBio	-,131**	-,092**	1						
9-FirmAge	-,020	,285**	-,260**	1					
10-TechCapital	-,061**	,156**	-,104**	,327**	1				
11-Breakthrough	-,019	-,002	-,019	,050**	,035**	1			
12-Novelty	,046**	,043**	,007	,000	,005	,168**	1		
13-PatentAge	-,002	,010	,018	-,004	,018	,304**	,248**	1	
14-Claims	-,012	-,023	,016	-,003	,004	,212**	,180**	,509**	1

*p<0.05; **p<0.01

Table 2. Results of random-effects negative binomial regression

	Model 1	s.e.	Model 2	s.e.	Model 3	s.e.
FirmSize	.073	.057	.040	.058	.001	.060
Ownership	.046	.096	.027	.096	.050	.096
Subsidiary	.105	.120	.074	.120	.073	.121
SubjectAreas	.010+	.006	.010+	.006	.0077	.006
DedicatedBio	-.119	.092	-.138	.092	-.118	.093
FirmAge	.001	.001	.001	.001	.000	.001
$TechCapital_{(t-1\ to\ t-5)}$	-.000	.000	-.000	.000	-.000	.000
$Breakthrough_t$	.018***	.003	.018***	.003	.018***	.003
$PatentAge_t$	.118***	.011	.116***	.011	.120***	.011
$Claims_t$	.067***	.002	.066***	.002	.068***	.002
$Novelty_t$	.012***	.001	.012***	.001	.011***	.001
$TechDiversification_{(t-1\ to\ t-5)}$					1.011***	.170
$GeoDispersion_{(t-1\ to\ t-5)}$			2.617**	.869	5.106***	1.260
$GeoDispersion^2_{(t-1\ to\ t-5)}$			-5.227**	1.882	-5.369**	2.042
$GeoDispersion_{(t-1\ to\ t-5)}$ X $TechDiversification_{(t-1\ to\ t-5)}$					-5.883***	1.143
Constant	-3.440***	.216	-3.487***	.218	-3.763***	.225
Waldχ^2	2315.37***		2335.56***		2313.70***	
Log-likelihood	-3392.43		-3387.78		-3364.28	

N=6,323; year dummies included

$^+$p<0.10; *p<0.05; **p<0.01; ***p<0.001