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Breadth of external knowledge sourcing and product innovation: The moderating role of strategic human resource practices

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ABSTRACT

Prior research has argued that external knowledge sourcing can be supported by effective strategic human resource (HR) practices. However, whether and how the adoption of new organizational mechanisms in group settings influences the relationship between external search strategies and innovation performance represents an unanswered question. Therefore, the present paper aims to explore the relationship between the breadth of external knowledge sourcing (i.e., external search breadth) and product innovation by unveiling the moderating effects of strategic HR practices, as represented by the implementation of heterogeneous work groups and brainstorming sessions. On the basis of data from the Italian Innovation Survey, our results reveal that external search breadth is curvilinearly (inverted U) related to product innovation, and its negative effects occur later in the presence of heterogeneous work groups and brainstorming sessions.

1. Introduction

Product innovation is crucial for firms to survive and improve their overall performance in the current dynamic and competitive market (e.g., Katila, 2002; Smith, Collins, & Clark, 2005; Zhou & Wu, 2010). Specifically, following the OECD (2005), with the term product innovation, we refer to the introduction of a product in the form of a good or service that is novel with regard to the current offerings. To be effective in product innovation, firms require extensive efforts in searching and recombining knowledge. Notably, a core area of research on product innovation draws on the recombinatory search literature (Katila, 2002; Schumpeter, 1934; Grimpe & Sofka, 2009; Fleming, 2001; Savino, Messeni Petruzzelli, & Albino, 2017), which argues that searching for knowledge, while identifying original combinations between past and new knowledge components, is at the basis of product innovation activities. In particular, some studies (e.g., Kogut & Zander, 1992; Rosenkopf & Nerkar, 2001) went deeper into the recombinatory perspective of innovation, highlighting the need to go beyond the original tendency of innovating companies to search for knowledge locally (i.e., within their boundaries), especially suggesting to employ external knowledge sources. In fact, it is unlikely that all the knowledge needed to innovate can origin and reside within the firm boundaries (Enkel, Gassmann, & Chesbrough, 2009). Rather, for many companies (e.g., Procter & Gamble, Deutsche Telekom, and General Electric), the ability to source and recombine knowledge from the external environment is becoming more and more as the key to sustain internal product innovation efforts, which is in line with the recent principles of open innovation (Chesbrough, 2003; Dahlander & Gann, 2010; Saebi & Foss, 2015).

However, benefiting from external search is not an easy task. Indeed, one of the major issues lies in the fact that the number of different external sources from which firms can acquire relevant knowledge is wide, so they should determine the breadth of external knowledge sourcing that maximizes product innovation performance (Laursen & Salter, 2006). On the one hand, the attitude to rely on a wide variety of external knowledge sources (hereafter, external search breadth) allows firms to overcome cognitive myopia (Levinthal & March, 1993), explore new knowledge areas, and develop mental models that stimulate knowledge recombination in product innovation (e.g., Laursen, 2012). On the other hand, the risks of over-search [i.e., the absorptive capacity problem, the timing problem, the attention allocation problem, and the not-invented-here (NIH) syndrome] (see Katz & Allen, 1982; Koput, 1997; Laursen & Salter, 2006) can exceed the benefits

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deriving from searching widely. Thus, an inverted U-shaped relationship between external search breadth and product innovation has been claimed (e.g., Laursen & Salter, 2006; Leiponen, 2012; Wu, 2014).

Despite the validity of this argument, organizations cannot themselves search, in the sense that the acquisition and exploitation of external knowledge is a task in charge of the various organizational members. Specifically, prior research (e.g., Leiponen, 2012; Van der Vegt & Janssen, 2003) underlined that the ability of firms to internalize and recombine external knowledge is strongly dependent on the implementation of organizational practices that allow their employees to engage in collective creative thinking and recombination processes. Therefore, external search breadth may be more (or less) effective depending on the firm-specific practices that each firm sets to organize knowledge workers. This recalls insights from the human resource (HR) literature (Beugelsdijk, 2008; Huselid, 1995), claiming that companies need to organize innovation activities by making use of strategic HR practices that can enhance employees' attitude at absorbing new knowledge in a timely manner, sharing information, and paying attention to novel recombination opportunities, with the ultimate aim of achieving the desired work behaviors and efforts contributing to innovation outcomes. Accordingly, it has been proposed that "organizational practices for managing innovation within the firm's boundaries are facilitators of external knowledge sourcing activities as they aim for successful mobilization and application of knowledge" by the firm's employees (Brunswicker & Vanhaverbeke, 2015, p. 1243, Batistič, Černe, Kaše & Zupic, 2016). Nonetheless, to the best of our knowledge, no empirical research has been conducted to elucidate whether and how the adoption of HR practices influences the relationship between external search strategies and product innovation.

Consequently, knowing that external knowledge sourcing and product innovation are still primarily people processes and that there is a need to know more about which organizational mechanisms and practices managers need to utilize to make innovation search more effective (Laursen, 2012), the main research question of this study is the following: what is the moderating effect of strategic HR practices on the relationship between external search breadth and product innovation? In particular, first, we aim at further proving the assumption of a curvilinear relationship between external search breadth and product innovation, which stands for the baseline hypothesis of this study. Second, by drawing on both the recombinatory and HR literature, we attempt to reveal how the implementation of HR practices devoted to organize knowledge workers in product innovation activities attenuates the downsides of external search breadth.

In detail, HR practices fall into three main dimensions: skill-enhancing, motivation-enhancing, and opportunity-enhancing practices (Jiang, Lepak, Hu, & Baer, 2012; Lepak, Liao, Chung, & Harden, 2006). The first two practices refer to the definition of hiring strategies and incentive systems, respectively. These do not reflect structural organizational choices devoted to improve employees' search and recombination behaviors, and thus, they are not in the focus of our study. In contrast, opportunity-enhancing HR practices are organizational mechanisms directly designed to empower employees for achieving organizational objectives and optimizing their levels and types of skill to handle new knowledge and create market value (Jiang et al., 2012). Thereby, we concentrate on this last set of HR practices, specifically analyzing whether and how the implementation of heterogeneous work groups and brainstorming sessions affects the relationship between external search breadth and product innovation. Work group heterogeneity entails the design of groups characterized by employees with different backgrounds and/or operating in different functional areas (Stock, Totzauer, & Zacharias, 2014). Differently, brainstorming is a practice that stimulates the interaction between employees for a short-to-medium time period, usually to solve a complex job by fostering creative ideas (Dodgson, Gann, & Phillips, 2013; Osborn, 1957). The interest in these two HR practices is not new in product innovation studies. Indeed, with the increasing appreciation of groups as a source of innovation (e.g., Taylor & Greve, 2006), whether groups represent effective management practices in group settings has gained increasing research attention (e.g., Beugelsdijk, 2008;; D'Alvano & Hidalgo, 2012). Notwithstanding, their role in supporting external search strategies is still an unexplored area of research. As a result, we can reformulate our main research question as follows: what is the moderating effect of the implementation of (a) heterogeneous work groups and (b) brainstorming sessions on the relationship between external search breadth and product innovation?

Drawing on, and combining insights from the recombinatory search and HR literature, the present paper develops hypotheses and tests them on the basis of an econometric analysis of the Italian Innovation Survey. Results corroborate the inverted U-shaped relationship between external search breadth and product innovation. Furthermore, we reveal that the negative effects related to sourcing knowledge from many diverse search channels occur later if heterogeneous work groups and brainstorming sessions are set to conduct product innovation activities. Therefore, this paper contributes to the literature on open innovation and HR by confirming the presence of shortcomings in broad searches and by empirically analyzing an understudied area of research, as represented by moderating effects of strategic HR practices on the relationship between external search breadth and innovation performance.

The remainder of the paper is structured as follows. Section 2 develops the hypotheses. Section 3 presents the research methodology. Section 4 outlines the results. Finally, Section 5 concludes the paper by discussing the main implications, limitations, and future research directions.

2. Theory and hypotheses

2.1. External search breadth and product innovation

Product innovation is a complex problem-solving process that is increasingly influenced by the effectiveness of firms' external knowledge sourcing strategies. These strategies entail the scouting of knowledge from various economic actors (competitors, suppliers, customers, research organizations, etc.), research opportunities, and public information sources, each of which constitutes a separate search channel that allows companies to tap into relevant market, operational, and technological information (Brown & Duguid, 2001; Laursen & Salter, 2006).

In line with this reasoning, many studies contend that external search breadth has a positive impact on product innovation. In fact, the creation and original recombination of knowledge set the basis to market new products (Katila, 2002; Smith et al., 2005), and external search breadth can sustain this process in several ways. First, having access to knowledge from diverse sources promotes variety, in that novel perspectives and research methods may be introduced into the decision-making process of new product development (NPD) projects (Grimpe & Kaiser, 2010). This helps firms to avoid cognitive myopia (Levinthal & March, 1993) and provides stimuli to engage in creative thinking and adopt new problem-solving approaches, which in turn favor the introduction of products that are sensibly different from the current offerings (Laursen, 2012). Second, companies that invest in broad external searches acquire a number of different knowledge components. As a result, their ability to come up with original knowledge

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combinations grows. Indeed, a greater knowledge stock may provide more recombination and cross-fertilization opportunities between new and past innovation ideas (Katila, 2002; Wu, 2014). Therefore, because product novelty has been associated with high recombination capabilities (Fleming, 2001), innovative products are more likely to be launched by those firms relying on diverse search channels. Third, when the breadth of external knowledge sources grows, the uncertainty related to the payoff arising from product innovation activities is mitigated because the likelihood to acquire knowledge that is relevant for a firm's product innovation activities is higher than in the case of sourcing knowledge from only a few search channels, thus fostering the launch of new products (Leiponen & Helfat, 2011; Leiponen, 2012). Finally, product innovating companies require both downstream and upstream complementary inputs (e.g., technological, market, manufacturing, distribution, and design knowledge) to recognize the wants and needs in the marketplace, link them with new scientific discoveries, and, ultimately, define the optimal product design (West & Bogers, 2014). Because, by definition (Laursen & Salter, 2006), external search breadth can facilitate the acquisition and recombination of those diverse types of knowledge, it makes firms more able to develop product innovations.

Despite these advantages, external search breadth is not without limitations, which often occur when multiple parallel search channels are considered for knowledge sourcing activities. The main costs related to an excessive external search breadth can be referred to the three over-search costs initially spotlighted by Koput (1997) and then reconceptualized by Laursen and Salter (2006)—i.e., the absorptive capacity problem, the timing problem, and the attention allocation problem—and to the NIH syndrome (Katz & Allen, 1982). The absorptive capacity problem refers to the cognitive limitations that firms face in acquiring and recombining knowledge from too many different sources. Indeed, companies often do not have the cognitive capabilities to identify the most valuable sources and related knowledge inputs (Laursen, 2012). In addition, editing and codifying too diverse external knowledge with the aim of making it understandable within the company and turning it into innovative product ideas become extremely complex because of the lack of internal knowledge resources and expertise (Cohen & Levinthal, 1990; Zhou & Wu, 2010). Consequently, uncertainties associated with product innovation activities are not reduced anymore; rather, they drastically increase and hamper the commercialization of innovative products. Furthermore, sourcing knowledge from diverse actors implies that the knowledge management routines of each organization should be understood by the acquiring firms (Leiponen & Helfat, 2010). Thus, very broad searches pose limits to the extent of knowledge that can be assimilated because it is difficult for a company to be aligned with the knowledge-processing systems of all the various external actors. Because of these shortcomings, firms compensate by relying on their existing knowledge and avoid engaging in creative thinking and recombination efforts (Ardito, Messeni Petruzzelli, & Albino, 2016a; Fleming, 2001), which instead are of vital importance for product innovation. The second main issue characterizing an excessive external search breadth is represented by the timing problem. Sourcing knowledge from many search channels increases the probability that new product ideas may come at the wrong time. In fact, given the wide amount of external knowledge and perspectives, firms may not be able to select the right time when exploiting a certain knowledge component, especially if knowledge components are of different nature (e.g., upstream vs. downstream), or propose a new product to the customers, which makes it difficult to design NPD projects (Koput, 1997; Laursen & Salter, 2006). The third reason why managing the inflow of knowledge from many diverse sources is not straightforward lies in the allocation of attention toward each search channel. That is, the attention allocation problem. In particular, managers and knowledge workers can only concentrate on a limited number of issues in product innovation (Koput, 1997; Ocasio, 1997). Accordingly, recent studies (Dahlander, O'Mahony, & Gann, 2016; Kim, Kim, & Foss, 2016) found that the broader the number of sources firms consider, the less their ability to allocate adequate attention to bring relevant external knowledge, ideas, and perspectives to fruition, thus limiting creative attitudes and the degree of knowledge components and problem-solving approaches that can be used in recombination activities. As a final limitation, the higher the tendency to rely on knowledge of external sources, the higher the likelihood that the NIH syndrome will be a behavioral response to external search breadth. This leads knowledge workers to reject new ideas from outside and get stuck into a myopic view of handling NPD projects (Antons & Piller, 2015), thereby hindering the potential to meet new customers' demands and come up with novel products.

The foregoing discussion highlights that external search breadth positively affects product innovation, yet relevant drawbacks arise when its level is excessively high. This suggests that there will be a moderate level of external search breadth that maximizes product innovation performance. Stated more formally,

Hypothesis 1. *External search breadth has a curvilinear (inverted U) effect on product innovation.*

2.2. Heterogeneous work groups and external search breadth

Heterogeneous work groups include employees with diverse backgrounds and/or belonging to different functional areas. So far, a number of studies have highlighted the important role that heterogeneous work groups play in (product) innovation activities. In particular, this refers to the superior capabilities that work group heterogeneity generates in managing information variety, given the possibility to pool together people with depth expertise in specific knowledge domains and nonoverlapping types of knowledge (e.g., Dahlin, Weingart, & Hinds, 2005). Although work group heterogeneity is not without limitations, mainly represented by potential cognitive conflicts between the diverse members (e.g., Xie, Song, & Stringfellow, 1998), we claim herein that the knowledge management capabilities arising from the implementation of heterogeneous groups are particularly relevant to sustain external search breadth.

First, as contended by Cohen and Levinthal (1990), the absorptive capacity problem may be alleviated by increasing variety in cognitive structures, which can be attained by staffing groups with heterogeneous members. Indeed, heterogeneity provides groups with members of diverse cognitive schemas and models for problem solving, which steer them toward particular knowledge sources, encompassing different institutional norms, habits, and rules (Laursen, 2012, Brown & Duguid, 2001). This means that firms may organize knowledge workers by matching each group member's background and functional competencies to the most proximate types of search channel (i.e., the specialization of labor), thus facilitating identification and internalization of the most promising knowledge coming from each external source (Shin, Kim, Lee, & Bian, 2012). Therefore, companies will be more familiar to the knowledge-processing mechanisms of the external actors they rely on, thus ultimately reducing the uncertainty undelrying the use of broad searches in product innovation (Subramanian, Choi, Lee, & Hang, 2016). Moreover, given the broader array of depth expertise, skills, and knowledge that are present within heterogeneous work groups, firms may better employ external knowledge coming from diverse channels because more possibilities exist to stimulate

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analogical thinking and nonobvious creative and recombination processes, which may in turn lead to better product innovation performance (Laursen & Foss, 2003; Shin et al., 2012). Of course, detrimental conflicts hampering cognitive processes between group members of diverse functions and/or backgrounds can emerge during interactions. Nevertheless, it is also true that non-routinely and complex tasks, such as external search and product innovation, likely boost those conflicts toward more creative and innovative solutions, thus providing individual members with more benefits than disadvantages (Shin et al., 2012, p. 199). Eventually, as compared to the absence of heterogeneous work groups, the negative returns of external search breadth related to the absorptive capacity problem will likely occur later if companies favor the creation of groups with mixed background and competencies.

Second, the timing problem will also be better managed by employing heterogeneous work groups. Indeed, when members with diverse yet in-depth expertise in a given knowledge domain are allowed to work together, firms might scout and integrate diverse types of external knowledge "more than does the accumulation of such information in separate departments" (Stock et al., 2014, p. 928). For instance, in the case of reliance on both downstream and upstream knowledge sources, heterogeneous groups may concurrently evaluate both types of knowledge and help firms to better link market knowledge to operational and technological opportunities. Thus, colocating diverse members may result useful to identify a wider range of valuable ideas from external knowledge while exploring each domain with sufficient depth (Paulus, Dzindolet, & Kohn, 2011; Zhou & Li, 2012), avoid loops between departments, coordinate overlapped phases, and take into account downstream development problems earlier in the processes (Tessarolo, 2007). As a result, companies will be more responsive to market and technological opportunities, which make them more likely to speed up decision-making processes and select the right time when exploiting a certain knowledge component and launching innovative products.

Third, the presence of experts in diverse domains implies that group members can differentiate their attention to a given knowledge source according to their background and expertise (Staats, Milkman, & Fox, 2012). This means that the attention allocation problem of a wide external search breadth can be alleviated by using heterogeneous work groups. In addition, as stated earlier, heterogeneity can be a source of cognitive conflicts, which may, however, be useful to stimulate group members to focus more attention in the search and recombination processes involving knowledge from various sources. Accordingly, conflicting viewpoints pushes group members to a more thorough analysis of other members' thoughts and an in-depth information elaboration (Beugelsdijk, 2008; Dahlin et al., 2005; Xie et al., 1998). Consequently, exposing knowledge workers to diverging and potentially surprising perspectives arising from the use of diverse search channels may lead companies to be more creative and develop innovative ideas and solutions. Thus, we hypothesize that

Hypothesis 2. *Establishing heterogeneous work groups moderates the relationship between external search breadth and product innovation such that the threshold level of external search breadth at which negative returns set in will be higher for those firms relying on group members with diverse background and functional competencies.*

2.3. Brainstorming and external search breadth

The implementation of brainstorming sessions has long been recognized as an effective mean to cope with complex problems, as in the case of product innovation. In particular, group members supported by firms in discussing and finding innovative solutions to a given problem develop relevant knowledge management capabilities owing to the social- and task-related group interactions, which in turn mobilize creativity, stimulate novel ideas, and allow better predictions of market needs (D'Alvano & Hidalgo, 2012;; Dodgson et al., 2013;; Hollins, 1999). These consequences of brainstorming can be particularly beneficial when knowledge workers are asked to handle product innovation activities by sourcing knowledge from many diverse search channels.

In detail, brainstorming may alleviate the absorptive capacity problem. Indeed, brainstorming gives rise to cognitive facilitation, whereby ideas from a single individual can stimulate long-run memory and spawn associations in the minds of the other members to generate more novel or useful ideas that they otherwise would not have considered (i.e., the phenomenon of chain reaction) (Kohn, Paulus, & Choi, 2011; Paulus, Levine, Brown, Minai, & Doboli, 2010). Thus, in the case of managing multiple knowledge sources, companies incentivizing those group dynamics can mitigate the problems associated with the presence of a high variety of perspectives and knowledge domains, given the increased productivity of group members engaged in brainstorming sessions. Certainly, interactive groups may suffer production blocking (Hollins, 1999) that might hamper benefits of brainstorming for external search breadth. For example, the flow of ideas may be interrupted because each member has to wait its turn to expose its thoughts, thus giving rise to forgetting problems, and group members may be afraid to share nonconventional ideas, which limits the potential to engage in creative and recombination processes (Hollins, 1999; Paulus et al., 2011). However, brainstorming presents rules aimed at limiting these problems (e.g., the avoidance of criticism, taking notes that can be used later in the session, and legitimization of novelty) (Litchfield, Fan, & Brown, 2011; Osborn, 1957) that might preserve its benefits toward external search breadth.

By establishing brainstorming sessions, companies may limit not only the absorptive capacity problem but also the timing problem. Accordingly, brainstorming is also used by firms as a means to envision and design NPD projects for the short- and long-run economic development, in turn favoring a deep comprehension of how to link novel knowledge and solutions to the market over time (Andriopoulos & Gotsi, 2006; Hollins, 1999). Moreover, in addition to stimulating innovative ideas, the chain reaction consisting of interactive groups also allows firms to speed up the selection process of the most suitable ideas to innovate. In particular, despite some argue that people barnstorming alone (i.e., nominal groups) outperform interactive groups in generating creative ideas (Kohn et al., 2011), final and important decisions cannot be made in isolation, especially if they are complex and must be made quickly (Devine, Clayton, Philips, Dunford, & Melner, 1999; Rietzschel, Nijstad, & Stroebe, 2006), as in the case of integration and implementation of a wide variety of knowledge components and resources. It follows that organizations implementing brainstorming sessions are less uncertain and more reactive in product innovation activities, and this advantage is likely to apply particularly when they rely on the acquisition of knowledge from too many different actors. In addition, brainstorming is used to exchange ideas for the planning of the future, thus providing firms with more information about the timing when certain products should be launched into the market and which external knowledge components and ideas should be exploited (Andriopoulos & Gotsi, 2006).

Brainstorming may also be adopted as a mean to alleviate the attention allocation problem. That is, knowledge workers do not naturally allocate the adequate attention to search and recombination processes without prompting (Litchfield et al., 2011). However, during brainstorming, group members are asked to generate novel useful ideas, i.e., the top management tends to encourage

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each member to devote the necessary time and attention to identify the most relevant external knowledge sources and related upstream and downstream information (Dodgson et al., 2013; Furnham, 2000). In addition, when people take part in brainstorming sessions, they feel to have an important role in the decision-making process of NPD projects (Furnham, 2000) because each of them can contribute to important decisions, thus increasing their commitment to innovation objectives and knowledge sourcing activities. Therefore, it is likely that the attention allocation problem will also occur later when firms set brainstorming sessions.

Finally, it is argued that formalized practices reduce the potential of employees to be externally oriented because rigid regulations reduce knowledge sharing behaviors (García-Granero, Vega-Jurado, & Alegre-Vidal, 2014; Vega-Jurado, Gutiérrez-Gracia, & Fernández-de-Lucio, 2008). In contrast, brainstorming stimulates free information sharing between people while avoiding the judgment of others' perspectives (Hollins, 1999; Mattes, 2014). These attitudes reduce the barriers toward the acceptance of others' ideas and can make group members more open-minded to external knowledge, thus reducing the emergence of the NIH syndrome (Antons & Piller, 2015). According to the foregoing discussion, we contend that:

Hypothesis 3. *Brainstorming sessions moderate the relationship between external search breadth and product innovation such that the threshold level of external search breadth at which negative returns set in will be higher for those firms relying on brainstorming.*

3. Data and methods

The Italian Innovation Survey was used as the data source to test our hypotheses. The survey is conducted on a 2-year basis by the Italian National Institute of Statistics on behalf of Eurostat and is strictly based on principles of the Community Innovation Survey, which examines innovation activities in the European countries at the firm level. In particular, we relied on the Italian Innovation Survey conducted during 2008–2010 because it is the only one that considers the implementation of HR practices. In total, 5971 questionnaires contained all the required information, which allowed us to base our econometric analysis on 5971 firm-observations.

The adoption of a national innovation survey (as in our case) is not new, as revealed by the wide number of studies that have recognized its suitability for research purposes (e.g., Ghisetti, Marzucchi, & Montresor, 2015; Klingebiel & Rammer, 2014; Laursen & Salter, 2006; Leiponen & Helfat, 2010). Indeed, first, national innovation surveys inform about firms' innovation activities, innovation outputs, and knowledge sourcing strategies. Second, the types and methods of question follow the definitions and descriptions of the Oslo Manual (OECD, 2005), thus reducing the potential misalignment between theoretical basis of innovation and the operationalization of variables. Third, with regard to interpretability, reliability, and validity, innovation surveys are presently very well known among companies, since the first version dating back to 2000, and have been a subject of extensive pretesting and piloting across diverse countries and industry contexts (Laursen & Salter, 2006). Furthermore, pilot surveys or interviews with respondents were made by the national statistics institutions to determine if they were actually able to answer the questions. Moreover, respondents that were reported to be innovators were subject to a follow-up telephone survey to improve the overall consistency of the survey and include more detailed information on the innovation outcomes (e.g., users of the innovation and who developed the innovation) (Arundel & Smith, 2013). This further improves the reliability of the survey data, although data collection was not under our direct control. Finally, nonresponse analyses are usually conducted by national statistic institutions to avoid systematic distortions in the data, and recent research reveals that common method issues do not represent a main concern (Mairesse & Mohnen, 2010). Nevertheless, we still conducted principal component analysis on our data, which confirms that common method bias is unlikely to affect our results because the first factor accounts for only the 6.05% of the total variance explained (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). The abovementioned discussion leads us to be confident about the suitability of our data.

3.1. Sample description

As outlined in the previous section, companies in our sample are located in Italy, with 36% operating in foreign markets. The Italian economy can be compared to other European ones. For instance, Italian industrial turnover, gross domestic product (GDP) per capita, and expenditures on GDP for some 50 categories of goods and services are comparable with the average of the Eurozone (EHER, 2015; OECD, 2013). Furthermore, Italian innovation performance is in line with the majority of European countries, as revealed by the European Innovation Scoreboard (European Commission 2016). Thus, our sample may be representative of a relevant part of Europe.

Table 1 presents the industry distribution of firms in our sample, revealing that most of the companies (73.19%) refer to the construction, manufacturing, and automotive sectors. Instead, Table 2 compares innovating and noninnovating firms, where the former are the companies that declared to have introduced a new to the market product (19.75% of the sample), as opposed to the latter. In particular, Table 2 shows that the two types of companies, on average, have similar turnover; conversely, boundary spanning behaviors are drastically different, in that innovating companies tend to adopt more search channels and establish interorganizational collaborations with more partners.

Finally, the Italian Innovation Survey asked respondents to identify the importance of each of the nine knowledge sources used in innovation activities. In Table 3, we reported the importance given by firms to each knowledge source and revealed that supplier, customers, consultants, and commercial laboratories/R&D enterprises seem to be the most relevant.

3.2. Variables

3.2.1. Dependent variable

Respondents to the survey are asked to provide the fraction of sales, in 2010, deriving from introduced goods and services that are new to the market. In line with some previous studies (Laursen & Salter, 2006; Leiponen & Helfat, 2010), we used this information to operationalize our dependent variable (*Product innovation*). Accordingly, the Oslo Manual first proposed that the outcomes of product innovation activities can be computed as the percentage of sales from new products (OECD, 2005). Indeed, this information directly assesses whether firms were able to launch innovative products while avoiding to consider the effects of other types of innovation activities, such as marketing, organizational, and process innovation (OECD, 2005). This makes us confident about the suitability of this operationalization.

3.2.2. Independent and moderating variables

The independent variable (*External search breadth*) was measured as the number of different search channels from which a company has declared to source knowledge during the survey period (see Laursen & Salter, 2006; Laursen & Salter, 2014;

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Table 1
Industry representation.

NACE	Industry	Number of firms	Percentage in sample
41–43	Construction	2027	33.95
10–33	Manufacturing	1291	21.62
45–47	Wholesale and retail trade; repair of motor vehicles and motorcycles	1052	17.62
49–53	Transportation and storage	509	8.52
64–66	Financial and insurance activities	277	4.64
69–75	Professional, scientific, and technical activities	269	4.51
58–63	Information and communication	257	4.30
36–39	Water supply; sewerage, waste management, and remediation activities	147	2.46
35	Electricity, gas, steam, and air conditioning supply	142	2.38
	Total	5971	100

Table 2
Innovating Vs. non-innovating companies.

	Innovating firms	Non-innovating firms
Percentage in sample	19.76	80.24
Turnover	16.39	16.25
No. of external knowledge sources	3.64	0.76
No. of partners	1.20	0.13

Leiponen & Helfat, 2010). Specifically, we followed the procedure proposed by Laursen and Salter (2014). First, we identified all the potential knowledge sources listed in the Italian Innovation Survey. Nine external sources were considered in the survey. For each source, respondents to questionnaire indicated whether the source has a high, medium, low, or no importance. Second, every source was coded as a binary variable on the basis of its importance where a value of zero reflects a source of no or low importance and a value of one indicates a source of medium or high importance. Finally, the nine resulting dummy variables representing the search channels were summed up, and the final value was divided by the highest possible number of sources (nine) to normalize the measure so that the resulting variable takes a maximum value of one and a minimum of zero.

To measure the two moderating variables, we referred to the question asking whether a firm during 2008–2010 has introduced new management practices to improve creativity and idea generation. Each firm has thus declared if it has attempted to implement heterogeneous work groups (interdisciplinary and/or cross-functional) and brainstorming sessions. Therefore, the first independent variable (*Heterogeneous work groups*) is a dummy variable with a value of one if a company has implemented heterogeneous work groups, zero otherwise. Similarly, the second moderating variable (*Brainstorming*) is a dummy variable with a value of one if a company has implemented brainstorming, zero otherwise.

Because we expected that the relationship between *External search breadth* and *Product innovation* will remain an inverted U-shaped at any level of the two moderating variables (i.e., will not become linear or U-shaped), we tested Hypotheses 2 and 3 considering only the interactions between each of moderating variable and the linear term *External search breadth* (see Aiken & West, 1991; Ardito, Messeni Petruzzelli, & Panniello, 2016b; Godart, Shipilov, & Claes, 2014).

3.2.3. Control variables

We included additional variables to improve the reliability of the model. First, we controlled for the firm size, as measured by the natural logarithm of a firm's sales (*Firm size*) in the first year of the survey period. Indeed, larger firms generate higher sales, all else being equal (Ghisetti et al., 2015; Klingebiel & Rammer, 2014). Second, we added a dummy variable taking the value of one if a company is part of a group (*Group*) (Grimpe & Sofka, 2009). Third, we accounted for the collaboration breadth (*Collaboration breadth*). This variable was computed following the same procedure of *External search breadth*, except for the fact that in this case we considered the different organizations with which a company has declared to formally collaborate with (Laursen & Salter, 2014). Fourth, we included a dummy variable reporting the introduction of monetary incentive systems (*Incentives*) during the survey period (value one) (Jiang et al., 2012) and another dummy taking the value of one if a firm has received public subsidies (*Subsidies*) (Czarnitzki, Hanel, & Rosa, 2011). Fifth, to control for market dynamics, we included a dummy variable taking the value of one if a firm considers market concentration to be an impediment to innovation of a high or medium importance (*Market concentration*) and another dummy taking the value of one if an uncertain market demand is considered as an obstacle to innovation of a high or medium importance (*Market uncertainty*) (Ardito, Messeni Petruzzelli, & Albino, 2015). Sixth, a set of six (out of seven) dummy variables indicating the percentage of employees with a university or doctoral degree was included. Specifically, the dummies correspond to a share of 0%, 1–4%, 5–9%, 10–24%, 25–49%, 50–75%, and >75% employees with a third-level degree

Table 3
Knowledge sources for innovation activities.

Knowledge source	Percentages				
	Not used	Low importance	Medium importance	High importance	Total
Suppliers	64.96	6.7	19.29	9.04	100
Customers	71.34	9.29	12.49	6.87	100
Competitors	74.58	12.04	10.63	2.75	100
Consultants and/or commercial laboratories/R&D enterprises	71.51	10.15	13.1	5.24	100
Universities	84.71	7.02	5.74	2.53	100
Public research centers	88.85	6.7	3.4	1.06	100
Conferences	73.17	11.05	12.66	3.12	100
Scientific publications	75.15	11.54	11.27	2.04	100
Trade associations	76.96	11.29	9.23	2.53	100

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(*Dummy degree*). The omitted category was the share of 0%. Seventh, we included dummies reflecting if a firm operates only in the national market, only in foreign markets, or both in national and foreign markets (*Dummy geo-market*). The omitted category in this case is the presence of the firm in both national and foreign markets. Finally, we included industry dummies to account for potential sectorial differences (*Dummy industry*).

3.3. Model specification

Our dependent variable is the fraction of sales from products that are new to the market. Thus, it assumes values between 0 and 1. This type of variable falls into the category of limited dependent variables (LDV). That is, dependent variables whose range of values is substantively restricted (Wiersema & Bowen, 2009; Wooldridge, 2012). In this case, conventional linear models (e.g., OLS) are less than ideal because resulting predictions may go outside the range of definition for LDV (Long, 1997; Wooldridge, 2012). Among the econometric approaches suggested to correct for this issue and better manage LDV, Probit, Logit, and Tobit regressions are the most suitable (Wooldridge, 2012). However, the use of Probit and Logit regressions can only be applied in the presence of dichotomy binary LDV (i.e., with values of either zero or one) (Wiersema & Bowen, 2009), which does not reflect our case. Indeed, our dependent variable, despite limited between 0 and 1, can assume continuous values within this range, so Logit and Probit cannot be adopted (Wooldridge, 2012). Conversely, in such a case, Tobit regression should be employed to overcome the limitations of Probit and Logit models because it allows us to well predict outcome variables that have the characteristic to be continuous but limited at the same time (McDonald & Moffitt, 1980). In line with this reasoning and according to some recent studies (Ardito et al., 2016a; Banerjee & Cole, 2010; Bertrand & Mol, 2013), we employ the Tobit regression to test our hypotheses.

4. Results

Table 4 presents descriptive statistics and pairwise correlations. The table shows that all values are below the 0.70 threshold, thus avoiding multicollinearity concerns (Cohen, Cohen, West, & Aiken, 2013). Table 5 presents the results of the Tobit regression. Partial models were used to present the results. Model 1 includes the control variables only. Model 2 presents the linear and squared terms of *External search breadth*. Models 3 and 4 include the moderating variables and respective interactions with *External search breadth*. Finally, Model 5 is the full model, which is used to test the hypotheses.

As revealed by Model 1, product innovation performance increases by enlarging the number of collaborating partners ($\beta = 0.368$, $p < 0.01$), when public subsidies are granted to companies ($\beta = 0.206$, $p < 0.01$), and with market uncertainty ($\beta = 0.052$, $p < 0.01$). Conversely, product innovation is hampered when market concentration is perceived as a relevant obstacle to innovation ($\beta = -0.036$, $p < 0.10$).

Model 5 provides support for Hypothesis 1, in that the linear term of *External search breadth* is positive and significant ($\beta = 2.136$, $p < 0.01$), although its squared term is negative and significant ($\beta = -2.024$, $p < 0.01$). However, to finally confirm the hypothesis, we graphed the predicted effect of external search breadth on product innovation (Fig. 1) (Zelner, 2009). In this way, we can control for the fact that the form of this relationship is an inverted U and that the threshold level after which negative returns set in falls within the data range (Haans, Pieters & He, 2016). Fig. 1 shows that those conditions are respected, thus confirming Hypothesis 1.

Model 5 also displays that the interaction terms between *External search breadth* and *Heterogeneous work groups* and between *External search breadth* and *Brainstorming* are positive and significant ($\beta = 0.173$, $p < 0.05$ and $\beta = 0.152$, $p < 0.10$, respectively), which is in line with Hypotheses 2 and 3, respectively.

To gain further insights on the moderating effects, we conducted a simple slope analysis (Zelner, 2009). In particular, we depicted the curvilinear relation between *External search breadth* and *Product innovation* in the presence and absence of heterogeneous work groups (Fig. 2) and in the presence and absence of brainstorming sessions (Fig. 3). The figures show that when heterogeneous work groups and brainstorming sessions are implemented to conduct product innovation activities, the threshold levels after which the negative returns of external search breadth set in shift to right, thus confirming Hypotheses 2 and 3. For robustness, we replicated all the models considering as the dependent variable the probability that a firm has launched a product that is new to the market (Leiponen & Helfat, 2010). Results of the Probit regression corroborate our previous findings.

5. Discussion, implications, and future research

In this paper, we focused on how the breadth of external knowledge sourcing affects product innovation and, more specifically, whether the implementation of two strategic HR practices (heterogeneous work groups and brainstorming) influences this relationship. On the basis of data from the Italian Innovation survey, we confirm the inverted U-shaped relationship between external search breadth and product innovation. We ascribe this finding to theories suggesting that broad searches increase creative thinking and recombination possibilities (e.g., Laursen, 2012, Leiponen, 2012), which ultimately facilitate the introduction of innovative products. However, after a certain level of external search breadth, those benefits are outweighed by the increasing complexities in

Table 4
Descriptive statistics and pairwise correlations.

	Min	Max	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11
1-Product innovation	0	1	0.050	0.154	1										
2-External search breadth	0	1	0.148	0.234	0.352**	1									
3-Brainstorming	0	1	0.740	0.440	−0.118**	−0.226**	1								
4-Heterogeneous work groups	0	1	0.660	0.475	−0.136**	−0.274**	0.566**	1							
5-Firm size	0	23.45	16.279	2.169	0.007	0.022	−0.009	0.010	1						
6-Group	0	1	0.370	0.482	0.148**	0.272**	−0.181**	−0.252**	0.026*	1					
7-Collaboration breadth	0	1	0.049	0.162	0.240**	0.501**	−0.211**	−0.223**	0.014	0.253**	1				
8-Incentives	0	1	0.890	0.309	0.015	−0.003	0.437**	0.372**	0.003	0.085**	−0.008	1			
9-Subsidies	0	1	0.120	0.325	0.221**	0.430**	−0.116**	−0.140**	−0.001	0.168**	0.396**	0.011	1		
10-Market concentration	0	1	0.390	0.488	0.008	0.032*	0.000	0.004	−0.010	−0.023	0.021	0.006	0.022	1	
11-Market uncertainty	0	1	0.440	0.496	0.035**	0.057**	0.002	−0.004	0.003	−0.050**	0.026*	0.009	0.010	0.431**	1

N = 5971; *p < 0.10; **p < 0.05.

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Table 5
Results of Tobit regression (with robust s.e. in parentheses).

	Model 1	Model2	Model 3	Model 4	Model 5
External search breadth		2.443*** (0.116)	2.136*** (0.128)	2.200*** (0.123)	2.136*** (0.128)
External search breadth^2		−2.170*** (0.130)	−2.024*** (0.130)	−2.042*** (0.130)	−2.024*** (0.130)
External search breadth X Heterogeneous work groups				0.263*** (0.063)	0.173** (0.079)
External search breadth X Brainstorming			0.260*** (0.067)		0.152* (0.084)
Heterogeneous work groups				−0.121*** (0.028)	−0.071** (0.036)
Brainstorming			−0.132*** (0.029)		−0.087** (0.038)
Firm size	0.002 (0.004)	0.002 (0.004)	0.002 (0.004)	0.002 (0.004)	0.002 (0.004)
Group	0.028 (0.021)	0.016 (0.021)	0.011 (0.021)	0.010 (0.021)	0.009 (0.021)
Collaboration breadth	0.368*** (0.043)	0.133*** (0.042)	0.142*** (0.042)	0.143*** (0.042)	0.144*** (0.042)
Incentives	0.011 (0.030)	0.018 (0.030)	0.053* (0.030)	0.043 (0.031)	0.057* (0.031)
Public subsidies	0.206*** (0.024)	0.043* (0.023)	0.043* (0.023)	0.046** (0.023)	0.045* (0.023)
Market concentration	−0.036* (0.019)	−0.042** (0.019)	−0.042** (0.019)	−0.042** (0.019)	−0.042** (0.019)
Market uncertainty	0.052*** (0.019)	0.039** (0.018)	0.037** (0.018)	0.037** (0.018)	0.037** (0.018)
Dummy geo-market	Included	Included	Included	Included	Included
Dummy degree	Included	Included	Included	Included	Included
Dummy industry	Included	Included	Included	Included	Included
Constant	−0.647*** (0.082)	−0.805*** (0.083)	−0.728*** (0.082)	−0.737*** (0.082)	−0.714*** (0.082)
F statistic	12.20***	14.45***	14.00***	14.11***	13.69***
Log-pseudolikelihood	−1980.23	−1563.00	−1553.89	−1553.46	−1551.28
Likelihood ratio test (over baseline model)	–	834.46***	853.54***	852.68***	857.89***
Pseudo R^2	0.265	0.420	0.422	0.423	0.424
Observations	5971	5971	5971	5971	5971

*p < 0.10; **p < 0.05; ***p < 0.01.

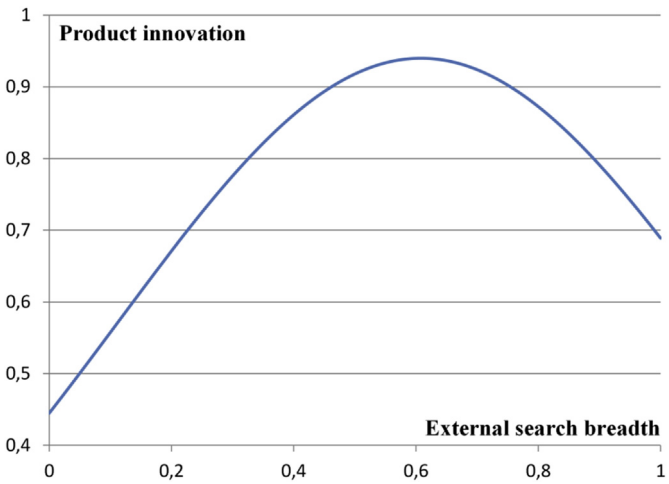

Fig. 1. Predicted effect of external search breadth on product innovation.

managing different search channels, defining the better time when exploiting certain knowledge components, and allocating attention to each knowledge source (Koput, 1997; Laursen & Salter, 2006). In addition, the NIH syndrome is likely to hamper the knowledge acquisition process needed to support internal product innovation activities (Katz & Allen, 1982). Furthermore, we revealed that the negative returns of external search breadth occur later if companies implement heterogeneous work groups and brainstorming sessions. In particular, we indicated that heterogeneous work groups can limit the drawbacks of searching broadly owing to the specialization of labor and a depth understanding of various knowledge domains (e.g., Shin et al., 2012; Stock et al., 2014). Brainstorming is instead important because it gives rise to cognitive facilitation, favors long-term planning, increases people's commitment to knowledge sourcing, and makes group members more open-minded (e.g., Andriopoulos & Gotsi, 2006; Hollins, 1999; Paulus et al., 2011).

Concerning the control variables, our analysis showed additional insights about product innovation performance. In particular, we found that enlarging the pool of partners with which companies collaborate and exchange knowledge favors product innovation. This is in line with research revealing the positive effect of alliance portfolio size on innovation performance (e.g., Lahiri & Narayanan, 2013), thus confirming the value of boundary-spanning activities. Furthermore, the perception of the market where firms operate should be also considered. Indeed, fear of uncertain market demand boosts product innovation because in such a situation, companies have to respond fast and concurrent to customers' needs, thus encouraging the launch of innovative products (Molina-Castillo, Jimenez-Jimenez, & Munuera-Aleman, 2011). Conversely, market concentration has a negative effect because the risks to compete with few companies that own the majority of the market share reduce the willingness to proceed with expensive and risky innovative projects (Soni, Lilien, & Wilson, 1993). Finally, public subsidies to innovation activities result in important-to-improve product innovation performance. This is reasonable given the additional funds companies may use to sustain search and knowledge exploitation processes (e.g., Czarnitzki et al., 2011). Among the not statistically significant control variables, we highlight *Firm size* and *Incentives*. Specifically, existing evidence on the role of firm size is contradictory, with several studies reporting that firms' size provide both benefits and disadvantages for innovation (see Ardito et al., 2015 for a review). Although monetary incentives, which relates to motivation-enhancing HR practices, do not seem to be strongly related to innovation performance, they cannot fully compensate the uncertain and complex tasks underlying innovation activities and do not directly improve the recombination capabilities of knowledge workers (Davila, 2003; Goodale, Kuratko, Hornsby, & Covin, 2011).

Our findings suggest two important theoretical implications. First, we contributed to the open innovation literature (e.g., Chesbrough, 2003; Dahlander & Gann, 2010), with a specific focus on how companies acquire knowledge from external sources. Accordingly, we provided further confirmation for the curvilinear relationship between the breadth of external knowledge sourcing and innovation performance. This is relevant because innovation processes require firms to master diverse knowledge, yet previous

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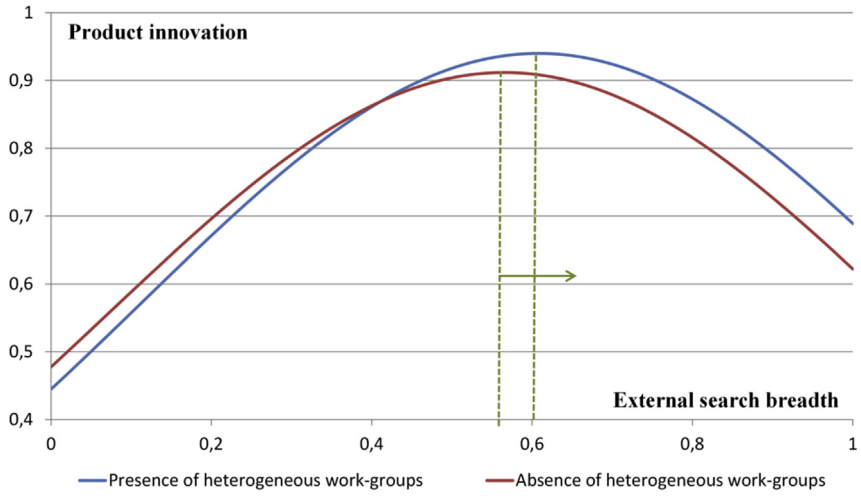

Fig. 2. Moderating effect of heterogeneous work-groups.

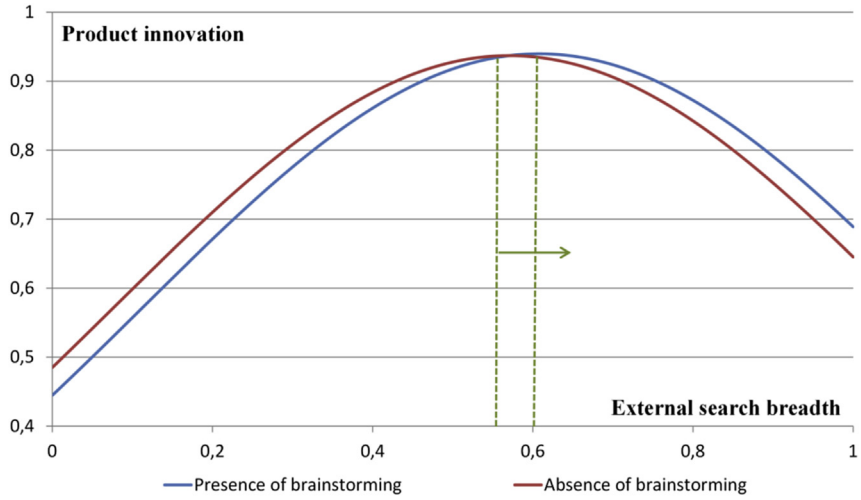

Fig. 3. Moderating effect of brainstorming sessions.

studies on this topic limited their analyses to firms in other countries (e.g., Germany and Finland) (Laursen & Salter, 2006; Leiponen & Helfat, 2010) or other types of innovation (e.g., eco-innovations) (Ghisetti et al., 2015), therefore requiring additional research to further corroborate our current understanding on this topic. Second, we advanced the idea of a link between open innovation and strategic HR practices. Indeed, although prior research has argued that external knowledge sourcing is mainly a people process that should be supported by effective organizational mechanisms (e.g., Laursen, 2012), to the best of our knowledge, this article stands as one of the first attempts in combining insights and providing empirical evidence for a link between studies on open innovation and HR, thus testing whether and how HR practices influence the effectiveness of external search strategies to innovate. Therefore, our findings also add to the literature on strategic HR practices (Beugelsdijk, 2008; Huselid, 1995) by investigating the potential benefits of HR mechanisms to boundary-spanning activities. Moreover, we further highlighted the important role of groups as a source of innovation (Taylor & Greve, 2006). Specifically, we emphasized that groups, as well as their effective design and management, are of particular relevance even in open contexts, thus also contributing to the literature on teams.

Moreover, control variables allowed us to refine our main theoretical implications. Accordingly, we contribute to the debate of openness in innovation search by underlying the role of collaboration breadth in increasing innovation performance (Lahiri & Narayanan, 2013). Indeed, Lavie (2007) noted that this finding has received the limited support in research. Moreover, the existence of significant effects of the environmental variables (i.e., *Market concentration, Market uncertainty, and Subsisidies*) also outlines that innovation is driven by factors beyond organizational boundaries. Finally, incentive systems have been revealed to not affect product innovation, which may indicate the different impacts of diverse types HR practice (e.g., motivation-enhancing vs. opportunity-enhancing) (Jiang et al., 2012), thus providing more insights to the HR literature.

Relevant implications for managerial practice can also be outlined from our findings. Accordingly, an emphasis was placed on the double-edged sword effect of external search breadth on product innovation. Thus, managers are advised that there is a moderate level of external search breadth that maximizes product innovation performance. This means companies should recognize the optimal number of different search channels from which to source external knowledge, in an attempt to avoid losing the

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relevant upstream and downstream information that are only available outside, while minimizing the cognitive constraints and impediments to the correct definition of NPD projects. To achieve this goal, managers should be aware that an adequate internal knowledge stock, in terms of diversity and fit, and an adequate understanding of the market (as also confirmed by the analysis of control variables) may reduce the cognitive limitations (e.g., Cohen & Levinthal, 1990) and timing issues (Koput, 1997) emerging from the inflow of knowledge coming from diverse search channels. Moreover, executives should create an environment that stimulates innovative ideas, learning, and boundary-spanning activities, so that knowledge workers will be more able and willing to focus on external knowledge sourcing activities (Antons & Piller, 2015; Vega-Jurado et al., 2008). Furthermore, we revealed that the use of heterogeneous work groups and brainstorming reduces the shortcomings of external search breadth, thus allowing firms to gain more advantages from broad searches. It is therefore of primary importance that managers and executives design external search strategies and the implementation of HR practices concurrently to better manage the inflow of external knowledge. This is of particular relevance because organizational boundary-spanning activities are drastically growing, and managers must be conscious of the management practices that should be implemented to improve subsequent innovation performance. In detail, we inform managers that employees in heterogeneous work groups may mitigate the drawbacks characterizing broad searches because each of them can increase cognitive variety, provide more problem-solving styles, and differentiate its attention according to its background and expertise. Instead, to better foster the creativity required to recombine external and internal knowledge components, brainstorming sessions should be set. Thus, implementing these types of HR practice may be useful when managers decide to engage in open innovation activities. However, it seems that motivation-enhancing HR practices do not gain similar benefits. Therefore, we warn executives to be aware of this finding when they attempt to acquire knowledge from many sources.

As with many other articles, this study presents some limitations that, however, suggest interesting avenues for future research. First, although the survey construction followed the well-established principles proposed by the Eurostat (Arundel & Smith, 2013), we have to acknowledge that some of the shortcomings related to the use of survey (e.g., inaccuracy in the answers, desirability issues, and delivering the question to the most suitable employees) were not under our direct control. Furthermore, the survey only allowed us to use a binary coding to represent the realm of HR practices, which indeed limits the possibility to fully capture their underlying dynamics. Therefore, future research may be based on new and ad-hoc surveys, with the aim of improving the reliability of the data and collecting more fine-grained information about the implementation of HR practices (e.g., actual rules, who decides their implementation, and how they are implemented), which may ultimately lead to a more through comprehension of the topic under investigation. Second, our data included only Italian companies. On the one hand, the Italian economy resembles many other European economies (EHER, 2015; OECD, 2013), and this may allow us to expect no significant changes will manifest in our findings. On the other hand, to confirm their external validity, future studies should deeply analyze how firms headquartered in other countries, especially non-European countries, adopt HR mechanisms to search external knowledge and their resulting innovation performance. Third, it may be important to delve into the role of external search breadth by identifying the relative significance of each search channel in fostering product innovation, and it might be interesting to unveil the best ways to jointly use diverse search channels. Fourth, in addition to work group heterogeneity and brainstorming, additional opportunity-enhancing HR practices may be considered, such as internal training, job rotation, and flexibility of working hours (Beugelsdijk, 2008). Finally, the influence of skill-enhancing and motivation-enhancing HR practices might be also included in future research.

In conclusion, this paper represents a first attempt to bring together theoretical arguments on external knowledge sourcing and strategic HR practices, recognizing that firms' employees are actually in charge of leveraging external knowledge to innovate. Thus, some interesting insights can be derived from this study; however, there are a number of opportunities for improvement and refinement of this line of inquiry.

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