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# The relationship between knowledge search strategies and absorptive capacity: A deeper look

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ABSTRACT

The present study analyzes how the breadth and depth of search strategies affect the dimensions of a firm's absorptive capacity: exploration, transformation and exploitation. Results of an analysis of a sample of 467 Spanish manufacturing firms reveal that openness of external knowledge search contributes to firms' exploratory, transformative and exploitative learning processes in different ways. In particular, a strong curvilinear effect of external knowledge search breadth on exploratory and exploitative learning was found. It is also important to establish deep relationships with external agents to achieve transformative and exploitative learning up to a certain point after which relationships become negative. Interestingly, for a firm to develop explorative learning, it is not important to establish deep relationships. And for a firm to develop transformative learning it is not important to establish broad relationships. Some suggestions for managers and future lines of research are provided.



## 1. Introduction

The reason why some companies are able to take advantage of knowledge from external sources and others are not has captured the attention of both academics and practitioners. Cohen and Levinthal (1989) used the term absorptive capacity (AC) to describe a firm's ability to recognize the value of new external information, assimilate it and apply it to commercial ends. Since then many researchers from different fields have identified various elements as antecedents of this concept, amongst which inter-organizational antecedents have received the most academic attention (Lane et al., 2006; Volberda et al., 2010; Enkel and Heil, 2014; Ferreras-Méndez et al., 2015; Roberts, 2015).

Some researchers have argued that different ways of acquiring new knowledge may lead to different modes of organizational learning (Chiang and Hung, 2010) that can be split into different processes, namely, explorative, transformative and exploitative learning processes (Lane et al., 2006). Exploratory learning is the acquisition of external knowledge, and it refers to the notion of potential absorptive capacity (Zahra and George, 2002; Enkel and Heil, 2014). Transformative learning corresponds to the maintenance of knowledge over time (Garud and Nayyar, 1994) and links exploratory learning with exploitative learning. And finally, exploitative learning refers to the application of acquired knowledge, and corresponds to the concept of realized absorptive capacity (Zahra and George, 2002; Patel et al., 2015). These learning processes are the mechanisms that originate and make possible the development of a dynamic capability inside the firm (Eisenhardt and Martin, 2000; Helfat et al., 2007).

Studies assessing the link between inter-organizational antecedents and AC dynamic capability have focused primarily on the characteristics of previous or related knowledge (Lane and Lubatkin, 1998; Lane et al., 2006; Wales et al., 2013). It has been highlighted that the nature and the kind of knowledge required by one of the collaborating firms may also affect knowledge transfer, particularly through the type of mechanism required for its transfer (Khamseh and Jolly, 2008). Therefore, other aspects such as the nature of the relationship, the search mechanisms, and the level of trust could influence the knowledge transfer and the development of AC (Khamseh and Jolly, 2008; Murovec and Prodan, 2009). How these relationships take place and how these strategies can affect the different stages of external knowledge absorption (Volberda et al., 2010) is a very interesting area of research. For instance, developing deep and broad relationships with external agents may generate noteworthy benefits for firms (Laursen and Salter, 2006; Chen et al., 2011; Cruz-González et al., 2015). The multidimensional approach of AC examines the effect that different external knowledge search strategies have on its dimensions (exploration, transformation and exploitation) and helps us to understand why some firms and not others are able to take advantage of knowledge from external sources. It may be the case that these relationships between external knowledge search

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strategies and the dimensions of AC do not always result in positive effects. One explanation for this phenomenon might be that collaborating with other organizations can lead to a leakage of key technologies and high costs for information search and knowledge integration (Chen et al., 2011). Another plausible explanation is that the managerial challenges posed by the three learning processes differ, so distinct components of prior knowledge may be critical in the three learning processes of absorptive capacity (Garud and Nayyar, 1994; Lane et al., 2006; March, 1991). Therefore, organizations may develop different strategies to facilitate the acquisition of the external knowledge necessary for their learning processes.

Following this logic this study contributes to extending the analysis of external knowledge search strategies. This research addresses, theoretically and empirically, how intensively accessing knowledge from a limited number of external channels (open search depth) and from a broad range of external sources (open search breadth) may be related to firms' exploratory, transformative and exploitative learning processes.

Previous studies suggest that searching widely and deeply has a curvilinear (inverted U-shape) relationship with performance (Laursen and Salter, 2006, 2014); however these studies did not consider what internal mechanisms might be involved in this relationship and may originate this type of effect. Because a firm's ability to apply the new external knowledge to its products and services depends on its level of absorptive capacity (Lane et al., 2006; Reza Saeedi et al., 2014), analyzing the effect of search strategies for this type of knowledge on the learning processes of absorptive capacity (exploration, transformation and exploitation) may provide further understanding of why some firms are able to take advantage of knowledge from external sources and others are not. To analyze this effect, the study draws on results from a survey completed in personal interviews with two different managers in 467 companies.

The structure of this paper is as follows. In Section 2, the literature is reviewed and three research hypotheses are proposed. Section 3 describes the methodology used in the empirical study and the characteristics of the sample data. Section 4 reports the results, and finally the conclusions and implications are discussed in Section 5.

## 2. Literature review and hypotheses development

### 2.1. The concept of absorptive capacity

Although Kedia and Bhagat (1988) first coined the term 'absorptive capacity', Cohen and Levinthal's (1989) contribution is generally regarded as the founding paper on the subject. This term has been analyzed at different levels: individual (Cohen and Levinthal, 1990; Minbaeva et al., 2003), business unit (Jansen et al., 2005; Szulanski, 1996), and organizational (Cohen and Levinthal, 1990). However, very few empirical studies have captured the rich theoretical arguments and the multidimensionality of the absorptive capacity construct (Murovec and Prodan, 2009). Some of the studies that modify Cohen and Levinthal's original definition alter the dimensionalization only slightly by limiting the construct to two dimensions: the first associated with the recognition, acquisition and assimilation of external knowledge, and the second, with its internal dissemination, reactivation and application.

One of the most important conceptualizations of AC since Cohen and Levinthal is that of Zahra and George (2002). This new conceptualization emphasizes the systems, processes, routines and structure of the organization that allow firms to identify, assimilate, transform and exploit external knowledge. These authors argue that absorptive capacity is a dynamic capability that has two general states: potential AC, which refers to the ability to value and acquire external knowledge; and realized AC, which reflects the capacity to leverage the knowledge that has been absorbed. Both subsets of AC have separate but complementary roles and fulfill a necessary but insufficient condition to improve firm performance. By defining absorptive capacity as a dynamic capability, Zahra and George emphasized the strategic nature of absorptive capacity.

Although Zahra and George's (2002) reconceptualization raises important issues about the components, antecedents, contingencies and outcomes of the construct, these authors do not sufficiently build on key insights from Cohen and Levinthal's (1989) original conceptualization. Furthermore, they only partly integrate into their model the substantial body of research on learning and innovation accumulated since the early seminal papers (Sun and Anderson, 2010).

Lane et al. (2006) reconceptualization is one of the first works to attempt to integrate the insights generated in previous studies into Cohen and Levinthal's (1989) original definition, and to link AC and organizational learning theoretically. These authors argue that AC represents a dynamic capability and the benefits of this capability depend on the underlying learning processes representing the mechanisms that allow an organization to purposefully create, extend or modify its resource base (Eisenhardt and Martin, 2000; Helfat et al., 2007). Therefore, following this process-based view Lane et al. defined AC as a firm's ability to utilize externally held knowledge through three sequential processes: (1) recognizing and understanding potentially valuable new knowledge outside the firm through exploratory learning, (2) combining existing knowledge with externally-acquired knowledge through transformative learning, and (3) using the assimilated knowledge to create new knowledge and commercial outputs through exploitative learning (Lane et al., 2006; 856).

Following Lane et al. (2006) definition, the precursors of the three learning processes differ. Exploration is stimulated by the desire to discover something new (Rotharmel and Deeds, 2004; 203) whereas transformation is prompted by the existence of explorative learning that can usefully be transformed for an exploitative purpose. Finally, the precursor of exploitation is the existence of an exploitable set of resources, assets, or capabilities under the firm's control (Rotharmel and Deeds, 2004; 203). Following this argument, transformation and exploitation depend upon prior exploration. Throughout the early stages of the new product development process a firm is prospecting for new wealth-creating opportunities (Rotharmel and Deeds, 2004; 203). During this creative stage, the company undertakes an exploratory search involving invention, basic research, risk taking, and building new capabilities with the aim of developing capabilities or new knowledge which it can subsequently exploit to create value (Cohen and Levinthal, 1989). Then, when the potentially valuable knowledge has been acquired through exploration, the firm transforms it into new skills and valuable knowledge, and finally it can be exploited. Thus, Lane et al. (2006) exploration–transformation–exploitation model implies a sequence for organizations to use these processes.

Later, Todorova and Durisin (2007) suggested that assimilation and transformation are parallel rather than sequential capabilities. They added feedback loop to the model and suggested that an identification capability comes before acquisition capability.

Volberda et al. (2010) study not only the process but also the antecedents, outcomes, moderators, and mediators of AC. Using bibliometric cartography they show that most attention has focused on the tangible outcomes of AC, but researchers have neglected the study of antecedents of AC such as the individual level and organizational design, and the interactions of individuals and organizations. These authors call for more research into the concept to show the micro and macro antecedents, and including

innovation, competitive advantages and firm performance as outcomes.

In response to this call Lewin et al. (2011) presented research on the microfoundations of internal and external AC. They propose a routine based model of AC that constitutes the operationalization of the construct, highlighting the importance of balancing internal knowledge creating processes with the identification, acquisition, and assimilation of new knowledge originating in the external environment. By identifying metaroutines they decompose the construct of AC into two components: internal and external AC capabilities, finding that the ability of organizations to discover and implement complementarities between AC routines may explain why some firms are successful early adopters and most firms are imitators.

This paper also responds to a call from Volberda et al. (2010) for more studies on the antecedents of AC. Adopting the three learning processes of Lane et al. (2006) and incorporating parallel rather than sequential capabilities (Todorova and Durisin, 2007), this study presents broad and deep connections with external agents as antecedents of AC learning processes. This research captures the multidimensional and dynamic nature of the concept by providing a framework that integrates the contributions from some key papers in the field. Contacts with external agents affect not only exploration but also transformation and exploitation learning.

### 2.2. The role of breadth and depth in exploratory learning

Due to rapid technological progress and changes in the business environment, inter-organizational collaboration for learning and innovation has become common in recent years (West and Bogers, 2014). The rising cost of R&D and the swift advance of technological knowledge make it impossible to maintain internally all the capabilities and knowledge required for production. Consequently, firms often need knowledge that resides outside their core competences. They must therefore collaborate with external agents in order to learn. In his seminal paper on open innovation, Von Hippel (1988) proposed four external sources for collaboration: suppliers, customers, competitors and universities. Since then, several authors have investigated these sources (Un et al., 2010). Later additions to these four sources were consultants, private R&D institutes, and public research institutes (Laursen and Salter, 2014). Empirical research in this domain reports evidence of different intensities or even contrary effects of external knowledge sources on firm innovation (Cruz-González et al., 2015: p. 77). Some papers even demonstrate that none of the four analyzed sources has a positive effect on innovation performance (Tsai and Wang, 2009). One possible explanation for these contradictory findings is that external knowledge acquisition by itself is not enough to increase a firm's innovative capability (Voudouris et al., 2012); rather, companies must necessarily develop the ability to transform the knowledge acquired into new products accepted by the market (Ferreras-Méndez et al., 2015). This explanation highlights the importance of analyzing the mechanism that allows organizations to successfully apply the newly incorporated knowledge into their processes, or into the products or services they offer (Caloghirou et al. 2004). This paper defends this idea by claiming that external sources may also help the company not only to explore new knowledge but also to have the capability to transform and exploit it. Specifically, we argue that the strategy firms use for external knowledge search may have a different effect on the firm, depending on which stage of the knowledge absorption it is in. Therefore, external sources affect the whole learning process of absorptive capacity: exploration learning, transformation learning and exploitation learning.

Laursen and Salter (2006) studied the influence of search strategies on external knowledge with the concepts of breadth and depth as two components of the openness of individual firms' external search strategies. Breadth is the number of separate search channels (sources of innovation)—such as suppliers, users, competitors, research organizations, and universities—that firms use in their search for innovative opportunities (Laursen and Salter, 2006, 2014). In contrast, depth is the extent to which firms draw from these external sources or search channels (Laursen and Salter, 2006, p. 135). Breadth and depth strategies are the components of the openness of individual firms' external search strategies. Firms that have open search strategies (those which search widely and deeply) tend to be more innovative up to a certain point, after which additional search becomes unproductive (Laursen and Salter, 2006). Our paper chimes with this idea by looking at the step before innovation; specifically we explain how absorptive capacity is generated. Our study shows how deep and broad relationships with external agents affect the three learning processes of absorptive capacity: exploration, transformation and exploitation.

With regard to the relationship between breadth and exploration learning, previous studies have shown that developing relationships with different external actors is positively related to exploratory learning (Ahuja and Lampert, 2001; Rowley et al., 2000; Laursen and Salter, 2014). One example of this could be the interaction with partners located in different lines of business, an interaction that often generates new ideas since these companies facilitate access to a different knowledge base (Daghfous, 2004; Dittrich and Duysters, 2007; Granovetter, 1973). Therefore, a firm seeking to increase its knowledge base to pursue a strategy of exploration for product development will often collaborate with partners from different sectors (Dittrich and Duysters, 2007). One of the characteristics of this search strategy is the development of weak ties with external agents that give firms sufficient flexibility to try different external sources and learn how to gain knowledge from them (Duysters and De Man, 2003; Laursen and Salter, 2006). When exploring a particular new technology, companies may not want to enter into inflexible relations with external actors, because they do not know whether or not the technology will prove useful to them (Dittrich and Duysters, 2007). Consequently, they want to have the opportunity to abandon the collaboration at any given moment (Duysters and De Man, 2003).

However, searching widely is not without its costs. Managers need to invest time and effort in understanding the different external knowledge channels because ex ante it is difficult for them to know which external knowledge source will be the most rewarding for the firm (Laursen and Salter, 2006; 136). Since search strategies are based on past experience, previous unrewarding collaborations may limit the location and the attention paid to using different external sources (Levinthal and March, 1993; 103). Laursen and Salter (2006) argue that as a result, managers may over-search external sources. We argue that to search external sources is positively related with explorative learning up to a certain point, after which it may become disadvantageous. Understanding and selecting what information could be useful for the firm can be tedious if too much information is available because the work of those responsible for it may be hampered by time-consuming activities. Some of these activities involve maintaining ties with different type of sources (consumers, competitors, universities, suppliers…). One example could be helping others in the network, and convincing others to provide help needed (Hansen et al., 2001). If a firm has many ties with different external sources, the time-consuming activities related to the network could even be counterproductive to acquiring new knowledge.

Koput (1997) suggested that the negative effect of oversearching on innovative performance might be a consequence of a

decrease in a firm's AC. According to this author the positive feedback (or valuable knowledge) obtained from using external sources of knowledge encourages further attention to the associated source. In fact, there is a limit to the positive effect of a network, as in every firm, capacity to allocate attention to search activities is finite (Koput, 1997; 533). If firms exceed their limit of external sources to which they can allocate attention they may find it difficult to explore the new knowledge. Therefore, oversearching may be detrimental to developing exploratory learning.

Considering the above, the following hypothesis is postulated:

**Hypothesis 1a.** : An inverted U-shaped relationship exists between the breadth of a firm's external knowledge search and its exploratory learning.

Another mechanism firms use to identify new knowledge sources is to develop deep relationships with a limited number of external sources (Laursen and Salter, 2006). In fact, strong relationships between parties are necessary for transferring complex knowledge associated with explorative learning that is new to the company. According to structural hole theory, strong ties facilitate both the higher volume and higher quality of information flow (Burt, 1992) that are necessary to understand the new knowledge. Messeni-Petruzzelli et al. (2010) suggest the importance of strong inter-organizational ties as mechanisms that enable the transfer of knowledge in their explanation of universities' network structures. When the knowledge firms need to innovate is tacit, close interactions are required with external actors to facilitate the transfer and combination of the knowledge with the existing knowledge base (Chen et al., 2011).

However, as in the case of broad relationships, some firms may rely too heavily on external collaboration to develop explorative learning. Increasing the number of in-depth relationships with external agents takes time and also requires resources (Laursen and Salter, 2006). Thus, relationships that are too deep may negatively affect explorative learning due to inefficiencies in the system generated to maintain the strong relationship with this type of external agent. In fact, the company must establish reciprocity in order to generate the trust required in any relationship in which tacit knowledge is to be transmitted. As a result, the company will invest too much time and too many resources in pursuing trust and reciprocity in order to maintain the relationship with the external agent, a relationship that will not compensate the company if it gives more than it receives, and will have a negative not a positive effect on explorative learning. Following the above reasoning, the following hypothesis is formulated:

**Hypothesis 1b.** : An inverted U-shaped relationship exists between the depth of a firm's external knowledge search and its exploratory learning

### 2.3. The role of breadth and depth in transformative learning

In order to allow the assimilation and retention of knowledge, transformative learning acts as a conduit between explorative learning and exploitation (Lane et al., 2006; Sun and Anderson, 2010; Waddell and Pio, 2014). It allows existing knowledge to combine with externally-acquired knowledge by integrating the views of the organization's workers (Waddell and Pio, 2014). A new collective schema therefore emerges (Sun and Anderson, 2010; 26). It occurs in a framework where a previous phase of learning does not have to conclude before continuing with the next step. Rather, the company goes through a continuous process where exploration, transformation and exploitation are seen as complementary rather than separate steps.

Research into transformative learning identifies two essential stages: *maintaining* assimilated knowledge, and *reactivating* this knowledge (Garud and Nayyar, 1994). Maintaining refers to the activities aimed at embedding knowledge in a repository so it shows some persistence and accessibility over time (Argote et al., 2003; 572). Through knowledge reactivation, firms access accumulated knowledge and bring it into use by internalizing it once again through experiences (Garud and Nayyar, 1994).

Maintaining knowledge for later use can contribute to corporate vitality as it increases return from technological investment by exploiting its store of technology (Garud and Nayyar, 1994). However, maintaining knowledge for future use is costly because resources must be assigned to keep the knowledge alive (Levitt and March, 1988) and there is ambiguity and uncertainty about its future strategic value (Daft et al., 1988). Given their limited organizational resources firms need to decide whether to maintain knowledge for future use or to generate it again when needed. In reaching this decision, networks can provide the necessary skills to know which internal knowledge to retain and commercialize (Rothaermel et al., 2007). This assumption leads us to suggest that firms may develop connections with external sources to gather the necessary knowledge to deal with the ambiguity and uncertainty of the future value of the internal knowledge. The same occurs when the company needs to reactivate its stored knowledge, as the company's network helps it to know which knowledge is most useful to reactivate.

Collaborating with a broad number of external actors affords more advice and possible solutions to transformative problems than collaborating with a smaller number, simply because there are more sources for the focal actor to brainstorm with and exchange views on which knowledge is more important to maintain and/or reactivate (Hansen, 1999; Hansen et al., 2001).

However, maintaining broad collaboration is costly because it takes time and resources. Firms must catalog sustained external connections and create organizational mechanisms to review the catalog, otherwise, according to Garud and Nayyar (1994; 376) “maintained knowledge vectors may be lost for all practical purposes.” Consequently, it is positive for a company to create connections with external agents to decide which knowledge to maintain and reactivate up to a certain point, after which these connections hamper the process. This leads to the following hypothesis:

**Hypothesis 2a.** : An inverted U-shaped relationship exists between the breadth of a firm's external knowledge search and its transformative learning process.

On the other hand, when firms draw deeply (i.e., when they obtain knowledge from small number of external sources), they sustain a pattern of interaction over time and build shared understanding and routines (Laursen and Salter, 2006). These types of connections allow firms to share even sensitive information because they are more trustworthy, detailed and accurate, and are the result of a continuing relationship (Jack, 2005; Miller et al., 2011). Furthermore, studies reported in the literature on alliances recognize that active participation and strong relationships are important preconditions for knowledge access and information sharing in network and collaborations (Reagans and McEvily, 2003; Van Wijk et al., 2008).

Deep collaborations necessarily require greater time than weak ties as they involve adherence to a norm of reciprocity, which implies that the focal actor puts the immediate pursuit of his or her own targets on hold so as to help others pursue their objectives (Hansen et al., 2001). Furthermore, such deep collaborations may constrain firms' ability to grow their business and may limit organizations to the resources and information present in the network. Thus even if deep external sources help the company to transform useful knowledge this may come at

a huge cost if there are too many deep relationships to maintain. Hypothesis 2b is therefore put forward:

**Hypothesis 2b.** : An inverted U-shaped relationship exists between the depth of a firm's external knowledge search and its transformative learning process.

### 2.4. The role of breadth and depth in exploitative learning

Exploitative learning is associated with matching knowledge and market opportunities (Rothaermel and Deeds, 2004) by transmuting the assimilated knowledge and applying it to commercial ends (Lane et al., 2006). This learning process occurs when the assimilated knowledge is implemented, thus ensuring its reuse (Lane et al., 2006; Sun and Anderson, 2010; Schaarschmidt and Kilian, 2014). When knowledge is transferred from external agents to boundary spanners within the firm, organizations may use this knowledge to create new products and processes or to improve existing ones (Bierly et al., 2009; Nätti et al., 2014). In both cases, collaboration with a broad number of types of external agents has been shown to assist firms in applying the newly incorporated knowledge for commercial ends.

For example, firms in the biotechnology industry tend to collaborate with downstream partners to obtain access to complementary assets that are critical to successful commercialization, such as market assets, marketing and infrastructure, technology and production facilities, and experience in managing critical clinical trials (Pisano, 1990; Baum et al., 2000, p. 7). These activities generally take place in the collaboration between biotechnology firms and established pharmaceutical and chemical firms where the former's lack of experience in commercializing ideas is made up for by their partner's expertize (Fisher, 1996). Organizations may also try to collaborate with upstream partners such as universities, research institutes and government laboratories, which are sources of up-to-date information or knowledge that can be vital in successful patent bids (Laursen and Salter, 2014; Baum et al., 2000). The recipient can use this up-to-date knowledge to solve problems that may arise when applying new ideas to products.

Although collaborating with a wide number of external partners seems to be positively related to exploitative learning, overextending this network of collaboration may become a drawback for the firm. The drawback effect may occur as a result of the paradoxes of firms' openness. For instance, a common problem facing firms when they try to access external knowledge is that, in return, they have to reveal some their own knowledge to external actors (Laursen and Salter, 2014). Therefore, firms that are involved with a broad set of external actors may need to establish formal methods such as patents or trademarks, or informal methods such as secrecy or lead times (Cohen et al., 2000; 8), to protect their own knowledge from being copied by competitors.

Although an emphasis on appropriability can be associated with effective external engagement, previous studies in the field of open innovation hold that an over-emphasis on setting formal or informal mechanisms of appropriability can have significant negative repercussions for the transfer and sharing of knowledge with external parties (Laursen and Salter, 2006; Chesbrough, 2006; Alexy et al., 2009; Reitzig and Puranam, 2009). For instance, large firms tend to require their staff to obtain authorization from the legal department before establishing relations with external agents, and to ensure collaboration agreements are in place before any knowledge interchange begins (Alexy et al., 2009; Laursen and Salter, 2014). The legal department may take a defensive position to ensure priority for subsequent patent claims (Davis and Harrison, 2001). This increase in the complexity of negotiations can hamper the development of emergent collaboration, as external partners may interpret it as a sign that the collaboration with the focal firm will be difficult (Laursen and Salter, 2014). These measures may also slow down the knowledge transfer processes as a result of increased bureaucracy and the probability of conflicts arising over control and ownership. Accordingly we argue that the scope of the relationships with external actors is positively related with exploitation learning up to a certain point, after which the result may become negative. This leads us to the following hypothesis:

**Hypothesis 3a.** : An inverted U-shaped relationship exists between the breadth of a firm's external knowledge search and its exploitative learning.

Studies in the literature on inter-organizational collaboration and networks suggest that intensive knowledge exchange between collaborators is necessary to successfully exploit external knowledge (Laursen and Salter, 2006; Kohlbacher et al., 2013; Mäkimattila et al., 2015). These types of relationships give rise to a pattern of interaction, a shared understanding, and common ways of working together between firms that facilitate the transfer of information, including sensitive information, between collaborators (Dyer and Singh, 1998; Laursen and Salter, 2006). For example, in the context of value co-creation in new technology B2B services, service providers need to understand what motivates customers in order to create value proposals that persuade them to get involved in value co-creation and continue that involvement (Komulainen, 2014). Therefore, suppliers nurture close relations with these actors to help them to overcome the problems they may face in exploiting technology and, at the same time, they may use this information to improve the technologies they provide. This interaction with the customer is important since if customers fail to learn how to use a technology service, they may either leave it unused, or replace the service with an alternative one (Komulainen, 2014; 2039). Furthermore, in manufacture-supplier relations, manufacturers need to maintain close trusting relations with suppliers in order to reduce access barriers to strategic information that suppliers put in place, and that have implications for companies' long-term decision making (Vázquez-Casielles et al., 2013). This information is vital, especially to manufacturers that use indirect distribution channels and need strategic information to implement their market orientation (Vázquez-Casielles et al., 2013; Dyer and Hatch, 2006).

However, an increment in the number of strong ties is likely to lead to redundant information because they tend to occur among a small group of actors in which everyone knows what the others know (Granovetter, 1973; Laursen and Salter, 2006), which hampers exploitation. Furthermore, as the information organizations retain in the exploitation phase is of a sensitive nature, sharing this knowledge may give rise to a potential risk of opportunistic behavior from collaborators. Therefore, although organizations may need to be open with external actors, they also need to put mechanisms in place that ensure they benefit from their innovation. This condition can be critical when firms sustain formal and long-term relations with external collaborators as the probability of knowledge spillover is higher (Laursen and Salter, 2014). As an increment in the number of mechanisms to ensure secrecy and protect lead time may deter potential collaborators and make knowledge sharing process more complex we suggest that deep relations facilitate the exploitation learning process up to a certain point, after which knowledge becomes more difficult to access, making the exploitation learning stage inefficient. Consequently:

**Hypothesis 3b.** : An inverted U-shaped relationship exists between the depth of a firm's external knowledge search and its exploitative learning.

Fig. 1 explains the model in which external knowledge search strategies are shown as antecedents of absorptive capacity.

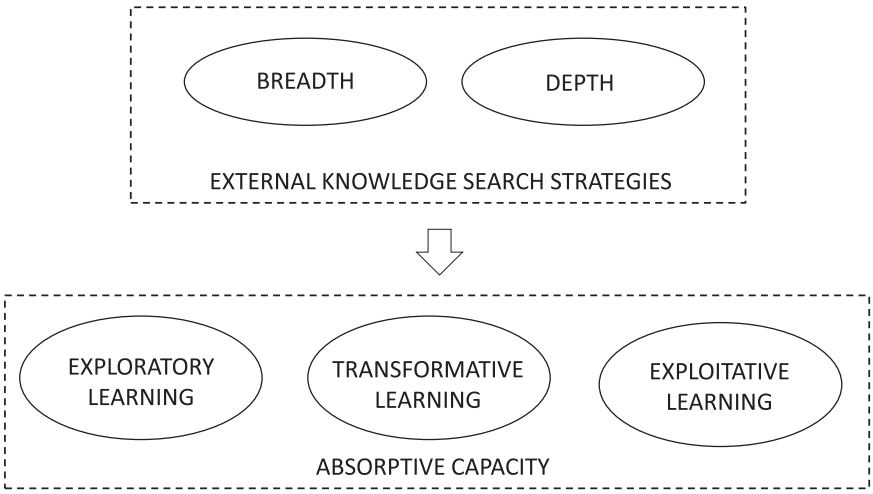


**Fig. 1.** External knowledge search strategies as antecedents of absorptive capacity.

## 3. Methodology

### 3.1. Data collection

Since external learning processes can differ substantially from one industry to another, our empirical study focuses on high-tech firms in biotechnology, middle-tech firms in the ceramics industry, and low-tech firms in the toy and footwear industries. Fieldwork was carried out in Spain from November 2011 to April 2012. We performed a pre-test with four experts to ensure that the questionnaire items were fully understandable in the context of the four industries. A total of 1217 firms were identified through industry directories. In order to obtain a representative sample we made initial contact by mail and telephone and then arranged appointments with respondents so that the questionnaire could be answered during a personal interview. We recruited trained interviewers to conduct on-site interviews in order to generate valid information and high-quality data. The interviewers presented the questionnaires to two managers separately. A subsequent feedback report was offered to the participating firms in order to encourage a higher response rate. A total of 478 firms agreed to participate in the study. Finally 467 completed questionnaires were obtained, representing around 38% of the target population. The sample firms have an average of 50 employees. Table 1 shows the sample structure. Most of the companies are SMEs; none of them is a listed company.

Non-response bias was tested by comparing the industries represented in the sample with the population sample in terms of size and revenues from sales and found no significant differences between the two groups. The answers for the independent and dependent variables were collected from two different respondents to avoid concerns on common method bias. Based on previous studies, the head of the R&D or a similar department was identified as the first informant for the organizational learning processes (absorptive capacity). The second informant was the CEO, who was assumed to have expert knowledge about knowledge search strategies (breadth and depth).

### 3.2. Measurement of the constructs

#### 3.2.1. External knowledge search strategies

Drawing from previous studies, external knowledge search strategies is measured using two dimensions: *breadth* and *depth* of external knowledge search (Chen et al., 2011; Laursen and Salter, 2006). *Breadth* refers to the diversity of the firm's relationships with different types of external partners. We included eight types of external partners (Murovec and Prodan, 2009) (see Annex): other enterprises within their enterprise group; suppliers of equipment, material, components or software; customers; competitors and other firms from the same industry; consultants; commercial laboratories or R&D enterprises; universities or other higher education institutes; and government or private non-profit research institutes. This dimension was operationalized as the number of types of external partners with which the firm had a relationship. Firms scored 0 when there was no relationship with a possible partner and 8 when they collaborated with all partner types. For example, a company that collaborates with universities and customers scores 2; one that collaborates with consultants, universities and customers scores 3, etc.

*Depth* of external knowledge search represents the intensity of relationships with external partners. In a previous study, Chen et al. (2011) measured depth from the score of the importance for

**Table 1**
Sample firm size and sector.

| | Number of employees | | | | |
|---|---|---|---|---|---|
| | Microenterprises (Fewer than 10) | Small enterprises (Between 10 and 49) | Medium enterprises (Between 50 and 249) | Large enterprises (Over 250) | Total |
| Ceramic tiles | 28 | 35 | 33 | 11 | 107 |
| Toy | 54 | 39 | 12 | 1 | 106 |
| Shoe | 61 | 70 | 18 | 1 | 150 |
| Biotech | 46 | 40 | 12 | 6 | 104 |
| Total | 189 | 184 | 75 | 19 | 467 |

Size categories correspond to the European Commission Recommendation, May 6, 2003.
(http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:124:0036:0041:en:PDF)

a firm's innovation activity of cooperating with eight types of external agents. The answers were based on an 8-point scale, where 1 represented low importance and 8 high importance. The average of the eight scores represented the depth of external knowledge search. The limitation of Chen et al.'s measure is that it does not allow us to distinguish cases in which a firm has a very deep relationship with a specific external agent from those in which the firm has less deep relationships with more external partners. For instance, using the Chen et al. (2011) methodology, a firm that values with an 8 its relationship with only one external agent and 0 for all the others will score the same average as a firm that indicates a value of 1 for all eight types of potential external partners. These behaviors are different; however with this measure they would be treated as equal.

In order to refine the measure of depth, we considered that a value from zero to six does not represent a deep relationship between the firm and the external partner, whereas scores of seven and eight represent deep relationships with the partner. This measure follows the approach of Laursen and Salter's (2006) measure where they score all relationships from 1 to 4 and then consider the value of 4 as a deep relationship. In this case, the measure scores from 1 to 8 and it considers values of 7 and 8 as a deep relationship. A score of zero was assigned to the values from 1 to 6 and a score of 1 to the values of 7 and 8. Therefore, firms have an average of 0 when there is no deep relationship, 1 when they collaborate with an external agent with a score of 7 or 8, 2 when they collaborate with two external agents with a score of 7 or 8, and a value of 8 when they have a deep collaboration (7 or 8 scores) with all partners.

#### 3.2.2. Absorptive capacity

The instrument used to measure absorptive capacity was developed following previous studies (Garud and Nayyar, 1994; Jansen et al., 2005; Marsh and Stock, 2006; Smith et al., 2005; Szulanski, 1996) (see Annex). According to this conceptualization, AC represents a multidimensional construct formed by three different but complementary learning processes, namely, exploratory, transformative and exploitative learning. Each of the learning processes represents second-order constructs.

*Exploratory learning* comprises the activities of *recognizing* and *assimilating* external knowledge. The former captures a firm's activities designed to scan and monitor external knowledge sources (Jansen et al., 2005; Szulanski, 1996) and the latter addresses the activities aimed at absorbing knowledge from external sources (Jansen et al., 2005; Szulanski, 1996).

*Transformative learning* includes the activities of *maintaining* and *reactivating* knowledge. *Maintain* captures a firm's activities of retaining and storing knowledge, and the way it shares and communicates knowledge internally (Jansen et al., 2005; Smith et al., 2005; Marsh and Stock, 2006), and *reactivate* captures whether a firm can quickly react to opportunities by relying on its existing knowledge, and its proficiency in addressing environmental changes by internalizing existing knowledge through experience (Garud and Nayyar, 1994; Jansen et al., 2005; Marsh and Stock, 2006).

Finally *exploitative learning* is formed by the processes of *transmuting* and *applying*. *Transmute* captures a firm's proficiency in combining new and existing knowledge and *apply* consists of four items and refers to a firm's proficiency in implementing technologies and their adaptation in new products (Jansen et al., 2005; Smith et al., 2005; Szulanski, 1996).

#### 3.2.3. Control variables

In this study two control variables are included, which may provide possible alternative explanations for its results. Firms' size may affect the flexibility and willingness of the firms to invest in the development of AC; we therefore included the *natural logarithm* of the number of full-time employees in the organization to account for firm size (Jansen et al., 2005; Veugelers, 1997). Secondly, environmental aspects may trigger organizations to develop their AC (Jansen et al., 2005; Zahra and George, 2002). Because firms often acquire external knowledge especially to respond to a turbulent environment (Cassiman and Veugelers, 2002), we introduced the construct turbulence to account for the type of changes in the environment (Jaworski and Kohli, 1993; Song et al., 2005). *Turbulence* relates to the rate of technological change and the degree of uncertainty within a firm's markets (Jaworski and Kohli, 1993; Helfat et al., 2007). It is measured on an 8-point scale with a measurement adapted from Jaworski and Kohli (1993) (see Annex).

Fig. 2 summarizes the model.

### 3.3. Psychometric properties of the measurement scales

The psychometric properties of the measurement scales were assessed following previous studies (Alegre and Chiva, 2008; Gatignon et al., 2002; Gerbing and Anderson, 1988; Tippins and Sohi, 2003) and included content validity, reliability, discriminant validity, convergent validity, and scale dimensionality.

*Content validity* was established through a review of the extant literature and through personal interviews with managers of these industries. The interviews confirmed that the questionnaire items were fully understandable in the context of the sectors analyzed.

*Reliability* represents the ratio of the true score's variance to the observed variable's variance. Table 2 shows the Cronbach's alpha coefficients (construct reliability column) and the composite reliability. The lowest index is 0.76 (maintain) above the recommended threshold of 0.7 (Hair et al., 1998; Iglesias, 2004; Nunnally, 1978). The lowest AVE index is 0.53, also exceeding the minimum standard of 0.5 (Hair et al., 1998; Iglesias, 2004). Our analyses therefore support the reliability of the measurement scales.

The constructs' *dimensionality* is checked through the loadings of the measurement items on the first-order factors, and the loadings of the first-order factors on the second-order factors. All scale items load significantly on their hypothesized construct factors (Hair et al., 1998). Fig. 3 shows that the standardized factor loadings are all significant ($p < 0.001$) and above 0.59, all of them exceeding the recommended threshold of 0.40 (Ford et al., 1986).

The *discriminant validity* was assessed through CFA by comparing the $X^2$ differences between a constrained confirmatory factor model with an inter-factor correlation set to 1 (indicating they are the same construct) and an unconstrained model with an inter-factor correlation set free. All $X^2$ differences were found to be significant, providing evidence of discriminant validity for the measurement scales (Anderson and Gerbing, 1988; Gatignon et al., 2002; Tippins and Sohi, 2003). CFA was also used to establish *convergent validity* by confirming that all scale items loaded significantly on their construct factors (Anderson and Gerbing, 1988). Additionally, convergent validity was also confirmed by comparing the $X^2$ differences between a constrained confirmatory factor model with an inter-factor correlation set to 0 (indicating that there is no relationship between the two constructs) and an unconstrained model with an inter-factor correlation set free. All $X^2$ were found to be significant, therefore providing evidence of convergent validity for the measurement scales.

The correlations between the variables included in the empirical analysis and the descriptive statistics are listed in Table 3. To examine the issue of multicollinearity, we calculated variance inflation factors (VIFs) in each of the regression equations. They were below the rule-of-thumb cut-off of 10 (Neter et al., 1990).

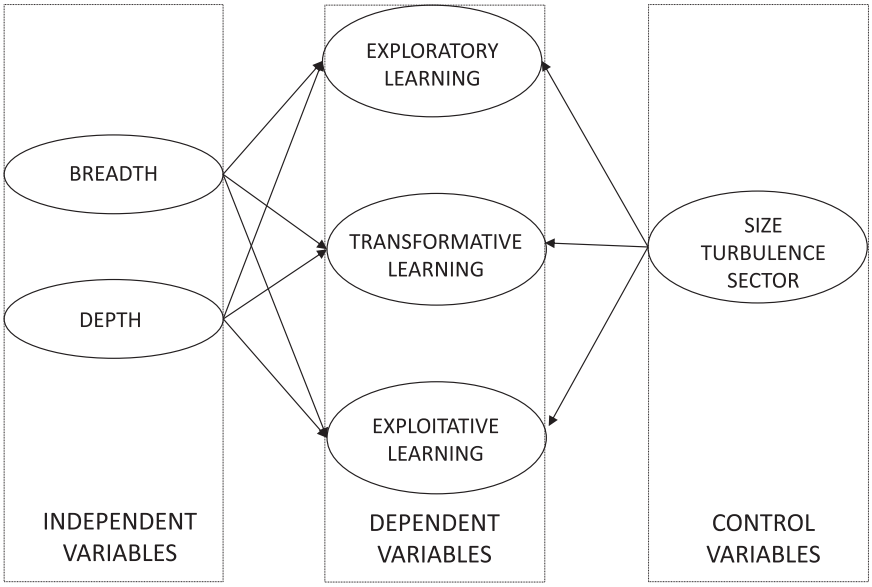


**Fig. 2.** Relational model.

**Table 2**
Construct reliability, composite reliability and variance extracted of learning processes.

| | Construct reliability ($0.70 < p < 1$) | Composite reliability (CR) ($0.70 < p < 1$) | Variance extracted (AVE) ($0.50 < p < 1$) |
|---|---|---|---|
| Recognize | 0.78 | 0.78 | 0.54 |
| Assimilate | 0.83 | 0.83 | 0.62 |
| Maintain | 0.76 | 0.77 | 0.53 |
| Reactivate | 0.80 | 0.82 | 0.61 |
| Transmute | 0.85 | 0.82 | 0.61 |
| Apply | 0.75 | 0.86 | 0.68 |

## 4. Results

Regression and Ordinary Least Squares (OLS) analyses were performed with SPSS software, following previous studies in this research stream (Laursen and Salter, 2014). This approach allows performing multiple regressions analysis and it has been widely used in studies about external knowledge search strategies and absorptive capacity (Kraaijenbrink et al., 2007; Murovec and Prodan, 2009). Table 4 presents the results of the regression models. The independent variables are external knowledge search strategies (depth and breadth). We included the square terms of depth and breadth to measure the curvilinear effects. The dependent variables are the learning processes; exploration, transformation and exploitation. In all the models, we included firm size, sector and turbulence as control variables.

The results for explorative learning process are shown in column A. Model 1 introduces the effect of external knowledge search strategies on exploratory learning. Both depth ($\beta = 0.120$; $p \leq 0.001$) and breadth ($\beta = 0.19$; $p \leq 0.01$) presented a positive and significant effect on the dependent variable. In Model 2, we introduce the square term of the variable breadth to test whether there is an inverted U-shaped relationship between the breadth of external knowledge search and exploratory learning. In this model, the coefficient of the squared term is negative ($\beta = -0.028$) and significant ($p \leq 0.01$). Hence, the results of Models 1 and 2 indicate that breadth of external connections is an important factor in explaining the exploratory learning process, but when firms establish too many relationships with external actors, their capability to acquire and assimilate starts to decrease. Therefore, we found a curvilinear relation in Model 2 between the breadth of external knowledge search and firms' exploratory learning that corroborates Hypothesis 1a. Finally, in Model 3, we introduce the square term of depth to test whether there is curvilinear relationship between this variable and explorative learning. The coefficient of the variable in this case is negative ($\beta = -0.009$) but not significant, which means that an increase in the intensity of relationships with external actors did not negatively affect explorative learning. Hypothesis 1b is not confirmed. An increase in the intensity of the relationship with external actors positively affects exploratory learning.

The results for transformative learning are shown in column B. Model 1 introduces the effect of external knowledge search strategy on the transformative learning process. The coefficient of breadth is positive ($\beta = 0.032$) and not significant. On the other hand, the coefficient of depth is positive ($\beta = 0.099$) and significant ($p \leq 0.01$), showing that only the depth of external knowledge is relevant for improving transformative learning. Model 2 introduces the square term of the variable breadth, and the coefficient is negative ($\beta = -0.026$) and significant ($p \leq 0.01$). This result confirms our Hypothesis 2a. Model 3 introduces the square term of the variable depth to test whether there is an inverted U-shaped relationship between depth and transformative learning. The coefficient of the square term is negative ($\beta = -0.028$) and significant ($p \leq 0.05$). Hypothesis 3b is therefore supported.

Results for exploitative learning are shown in column C. The first model shows that the coefficient for depth is positive ($\beta = 0.142$) and highly significant ($p \leq 0.001$). The coefficient for breadth is also positive ($\beta = 0.064$) and significant ($p \leq 0.01$). In the following model, we introduce the square term of the variable breadth. The coefficient of the variable is negative ($\beta = -0.021$) and significant ($p \leq 0.05$). Hypothesis 3a is therefore supported. In Model 3, the coefficient of the square term of the variable depth is negative ($\beta = -0.035$) and significant ($p \leq 0.01$), thus supporting Hypothesis 3b and confirming the inverted U-shaped relationship between depth of external knowledge search and exploitative learning.

With regard to the control variables, firm size (measured with ln of number of employees) and turbulence are significant and positive in the models of explorative learning. The biotech sector is also slightly significant in the models in which the dependent variable is explorative learning but not in transformative and

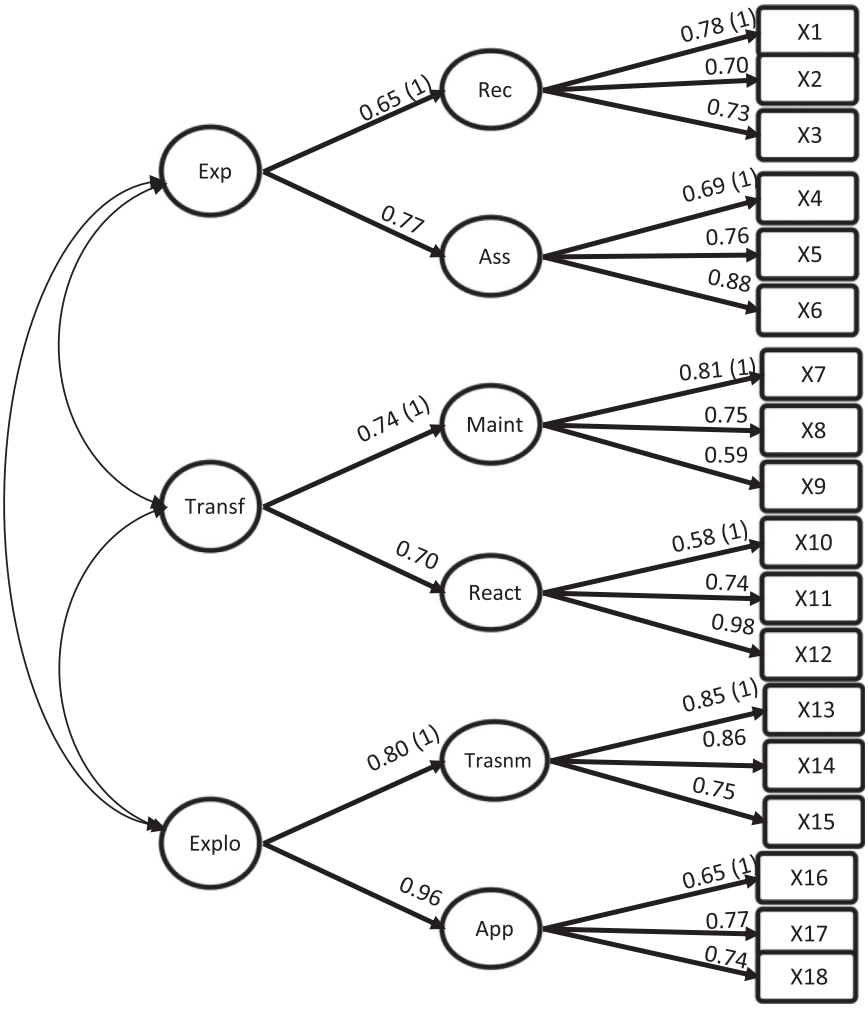


**Fig. 3.** Confirmatory factor analysis of learning processes. Note: (1) the parameter was equaled to 1 to fix the latent variable scale. Parameter estimates are standardized. All parameter estimates are significant at a 95% confidence level ($t \geq 1.96$).

**Table 3**
Factor correlations, means, minimum, maximum, standard deviations and Cronbach's alphas.

| | Mean | s.d. | Min. | Max. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Depth | 1.45 | 1.81 | 0 | 8 | | | | | | | | | | |
| 2. Breath | 4.60 | 2.68 | 0 | 8 | 0.76** | | | | | | | | | |
| 3. Exp | 5.46 | 1.61 | 1 | 8 | 0.473** | 0.492** | | | | | | | | |
| 4. Trans | 6.16 | 1.17 | 1.5 | 8 | 0.221** | 0.147** | 0.521** | | | | | | | |
| 5. Expl | 6.00 | 1.20 | 1.33 | 8 | 0.37** | 0.297** | 0.684** | 0.741** | | | | | | |
| 6. Ln Empl[a] | 2.74 | 1.38 | 0 | 7.48 | 0.267** | 0.324** | 0.271 | 0.050 | 0.118* | | | | | |
| 7. Turbulence | 4.80 | 1.50 | 1 | 8 | 0.214** | 0.211** | 0.249 | 0.052 | 0.166** | 0.108* | | | | |
| 8. Ceramic | 0.23 | 0.42 | 0 | 1 | 0.016 | 0.014 | 0.007 | −0.041 | −.048 | 0.276** | 0.216** | | | |
| 9. Shoe | 0.32 | 0.47 | 0 | 1 | −0.228** | −0.249** | −0.206 | 0.001 | −0.104* | −0.106* | −0.469** | −0.375** | | |
| 10. Biotech | 0.22 | 0.42 | 0 | 1 | 0.418** | 0.407** | 0.321* | 0.104* | 0.216** | −0.014 | 0.209** | −0.292** | −0.368** | |
| 11. Toy | 0.23 | 0.42 | 0 | 1 | −0.177** | −0.141** | −0.097* | −0.063 | −0.051 | −0.144** | 0.092 | −0.295** | −0.373** | −0.290** |

Note: $n=467$.
Cronbach's alphas are shown on the diagonal.
** Statistically significant correlation at $p < 0.01$.
* Statistically significant correlation at $p < 0.05$.
[a] Logarithm of the number of full-time employees.

**Table 4**
The effect of external knowledge search strategies on exploratory, transformative and exploitative learning process.

| | **Column A Explorative learning** | | | **Column B Transformative learning** | | | **Column C Exploitative learning** | | |
|---|---|---|---|---|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Model 1 | Model 2 | Model 3 | Model 1 | Model 2 | Model 3 |
| *Control variables* | | | | | | | | | |
| Ln employees | 0.164** | 0.173*** | 0.164*** | 0.039 | 0.018 | 0.009 | 0.039 | 0.046 | 0.039 |
| | (0.51) | (0.05) | (0.05) | (0.04) | (0.04) | (0.04) | (0.04) | (0.04) | (0.04) |
| Turbulence | 0.129** | 0.134** | 0.128** | 0.045 | 0.032 | 0.023 | 0.078* | 0.082* | 0.073+ |
| | (0.05) | (0.05) | (0.05) | (0.04) | (0.04) | (0.04) | (0.04) | (0.04) | (0.04) |
| Ceramic industry | −0.176 | −0.176 | −0.173 | −0.127 | −0.158 | −0.148 | −0.247 | −0.246 | −0.234 |
| | (0.200) | (0.20) | (0.20) | (0.161) | (0.165) | (0.166) | (0.17) | (0.17) | (0.17) |
| Shoe industry | −0.068 | −0.041 | −0.072 | 0.113 | 0.128 | 0.092 | −0.035 | −0.014 | −0.050 |
| | (0.191) | (0.19) | (0.19) | (0.161) | (0.158) | (0.159) | (0.16) | (0.16) | (0.16) |
| Biotech industry | 0.375+ | 0.426* | 0.375+ | −0.013 | 0.033 | −0.014 | 0.049 | 0.088 | 0.048 |
| | (0.210) | (0.21) | (0.21) | (0.75) | (0.174) | (0.175) | (0.18) | (0.17) | (0.17) |
| *Ext. knowledge search strategies* | | | | | | | | | |
| Breadth | 0.190*** | 0.175*** | 0.188*** | 0.032 | 0.019 | 0.025 | 0.064** | 0.053* | 0.055* |
| | (0.03) | (0.03) | (0.03) | (0.03) | (0.03) | (0.03) | (0.03) | (0.03) | (0.03) |
| Depth | 0.120** | 0.123** | 0.147** | 0.099** | 0.102** | 0.177*** | 0.142*** | 0.145*** | 0.242*** |
| | (0.04) | (0.04) | (0.06) | (0.04) | (0.04) | (0.05) | (0.04) | (0.04) | (0.05) |
| Breadth$^2$ | | −0.028** | | | −0.026** | | | −0.021* | |
| | | (0.01) | | | (0.01) | | | (0.01) | |
| Depth$^2$ | | | −0.009 | | | −0.028* | | | −0.035** |
| | | | (0.01) | | | (0.01) | | | (0.01) |
| R-square | 0.31*** | 0.33*** | 0.32*** | 0.05** | 0.07*** | 0.06*** | 0.14*** | 0.16*** | 0.16*** |

*Note*: standard error in parenthesis.
** $p \leq 0.01$;
*** $p \leq 0.001$.
* $p \leq 0.05$;
+ $P \leq 0.10$.

exploitative models. Turbulence is significant with exploitative learning as the dependent variable. However, when transformative learning is included as the dependent variable there is no significance between the control variables.

## 5. Discussion

Previous studies suggest that searching widely and deeply across a variety of search channels can provide ideas and resources that help firms to gain and exploit innovative opportunities (Laursen and Salter, 2006; Chen et al., 2011). However, a precondition to successfully internalize and commercialize external knowledge obtained from collaborations with external sources is to have the necessary absorptive capacity to first recognize the value present in the knowledge, assimilated and apply it for commercial ends (Spithoven et al., 2011; Ferreras-Méndez et al., 2015). This study corroborates this idea following most research using Cohen and Levinthal's conception of AC that suggest that higher internal AC helps firms to capitalize on external sources of innovation (West and Bogers, 2014). However, previous studies present conflicting predictions about the aforementioned effect. On one side, some studies suggest that absorptive capacity reduces the need for collaboration, while on the other, the argument is that it increases the likelihood of firms seeking collaboration (West and Bogers, 2014; 821; Ferreras-Méndez et al., 2015). The present study provides further understanding of the above conflicting view by analyzing the connection between the adoption of knowledge search strategies, breadth and depth, and the development of a firm's AC.

### 5.1. Theoretical implications

The findings of this study strongly suggest that sustaining weak ties with agents from a different line of business allows firms to broaden the pool of technology and market opportunities available to them, which help to increase their exploratory learning. As this type of collaboration does not necessary involve a two-way learning interaction, it provide firms with enough flexibility to be able to leave an external source, depending on the relevance of the collaborator's knowledge base and the benefits firms may obtain from it. However, when firms need to acquire tacit or more complex knowledge from external collaborators (for transformation and exploitation purposes), sustaining close and deep relations with external collaborators may allow them to generate the truth necessary to facilitate the transfer of information located outside their boundaries.

When the firm's strategy is to retain the newly assimilated knowledge and reactivate it for later application, our finding suggest that firms should develop sustained collaborations with external sources rather than relationships with a broad number of collaborators. One example of these external sources for developing deep collaborations are sector research centers that assist firms in internalizing new knowledge. These institutions act as knowledge agencies that help the member firm to tackle problems or implement technologies, thus improving the transformation capability of the knowledge receptor (Spithoven et al., 2011). As this type of collaboration and service is very firm specific and individual oriented, firms need to sustain deep collaborations to facilitate the evaluation of the initial idea and to solve the deficiencies that may arise during the process prior to implementation. This reasoning may explain why developing broad collaborations did not have a significant effect on transformative learning (see Table 4). However, there is a relationship between deep knowledge search strategies and transformative learning. We suggest that this is because the resources available to firms are limited. Consequently, they need to choose which knowledge to maintain in their knowledge base for later applications. However, this process may be somewhat ambiguous due to the difficulty of

forecasting the future value of the knowledge (Daft and Lengel, 1986; Spinthoven et al., 2011). Therefore it will be more beneficial for firms to maintain close collaboration with a limited number of collaborators in order to identify the best knowledge to retain. Furthermore this relationship between deep search strategies and transformative learning remains positive up to a certain point, after which it becomes negative. Hence, close relationships in this phase must reach the appropriate level in which knowledge leakage and expenditure on resources and time do not exceed the benefits of the relationship.

Finally, when firms want to apply the assimilated or transformed knowledge to improve existing products and processes or to generate completely new ones, our study shows that both external knowledge search strategies are beneficial. On the one hand, having a broad number of collaborators located at different stages of the value chain brings the company additional knowledge that they can access to solve problems that may arise when matching knowledge with processes and market opportunities. On the other hand, when a specific type of knowledge and the potential source of that knowledge have been identified, then firm may need to maintain a more formal collaboration with this type of agent. This is mainly because formal collaborators help to generate a pattern of interactions and a shared understanding between collaborators that is necessary to dispel any fears of the collaborator appropriating the shared knowledge without consent (Laursen and Salter, 2014).

Although openness in external knowledge allows firms to increase their innovation outcome, evidence in the literature suggests that over-search may hinder a firm's innovation performance (Ahuja and Katila, 2001; Laursen and Salter, 2006). Our study extends previous findings and confirms that the decrease in firm innovation outcome may be related to deficiencies in its AC. For instance, the optimistic view of managers who place too much emphasis on openness when exploring the environment for new ideas (Laursen and Salter, 2014) may hinder them from identifying in advance the structures required to support an increase in search channels or deep connections. Therefore, having more collaborators than structures can cope with may cause problems for firms in recognizing the potential value present in the new knowledge sources and in transferring this new knowledge within the organization.

Furthermore, when the firm wants to transform and apply the new knowledge, over-search may be counterproductive as a consequence of increased use of appropriate mechanisms or knowledge redundancy. As the knowledge that firms retain at this stage is more explicit and market applied, there is a higher risk that it may spillover to the market. Therefore, an increment in the number of external collaborators and depth of connections may be followed by more restricted mechanisms to ensure profit, which slow down the firm's ability to match knowledge and market opportunity. Moreover, managers should be cautious about increasing the intensity of the connections with external actors as they may become too heavily reliant on these sources and may constrain the firm's ability to extend its knowledge base.

### 5.2. Managerial implications

From a practical perspective, this research suggests that managers should be aware not only of the importance of developing wide and deep relationships with external actors in order to improve their AC, but also of the right balance for the company to be breadth and depth oriented. To generate competitive advantage managers need to develop strategies that generate synergies between the external knowledge search and the assimilation, transformation and exploitation of the incorporated knowledge. These strategies are important because deficiencies in any of the phases of the learning processes may be just as detrimental as the complete lack of AC (Argote et al., 2003; Marsh and Stock, 2006). Managers should therefore balance the intensity and the breadth of relationships depending on which stage of the absorption process they find themselves in. For instance, when attention is on recognizing and assimilating external knowledge (exploratory learning) the focus should be on creating an environment that maximizes the scope and the intensity of the collaborations to successfully increase the firm's knowledge base. However, when attention is on retaining the assimilated knowledge, the focus should be on creating an environment that maximizes the frequency and intensity of interactions with key partners. In both actions, managers need to bear in mind any limitation in the structures and systems for allocating attention to search activities and how to solve the problems that may arise in the process (Koput, 1997). In addition, when the attention is on the exploitation of the transformed knowledge, the focus should be on both increasing the scope of the network and the intensity of collaboration with it up to point. So, it is also important to find the right balance of relationships in this exploitation phase.

### 5.3. Limitations and future research

This study has some inherent limitations that also suggest future research lines. First, the data were gathered at one point in time, which prevented us from studying causal relationships among the variables analyzed. A longitudinal study may provide further insight into the dynamic of the learning processes and how they allow a firm to generate competitive advantage from knowledge from external sources. Another limitation is the operationalization of the measure of breadth, which does not capture the number of collaborations or actors that a firm may sustain with the same type of external agent. Furthermore, the operationalization of depth does not take into account the duration of the collaboration with the external agent. Future studies addressing the aforementioned limitations would be very welcome.

Further avenues of research on external knowledge search strategies could include network analyses. Network studies in specific industries can help discover whether networking has different requirements for increasing absorptive capacity, even identifying hierarchical networks where dominant firms with higher profit shares unilaterally affect the relationship.

Future studies may also assess how the use of different protection mechanisms can affect the relation between the knowledge search strategy adopted and the firm's capacity to explore, transform and exploit the new knowledge. Firms involved in collaborations with external partners may choose between different types of mechanisms to reduce fears of opportunistic behavior from external actors (Teece, 2002). However an emphasis on appropriability may involve firms in legal battles over patent ownership and divert their attention from developing new products (Bessen and Maskin, 2009). As managerial attitudes to openness and appropriability are very closely related (Laursen and Salter, 2014; 10), future studies could evaluate how adopting formal and informal mechanisms of appropriability could determine their efficiency in increasing AC from collaboration with external agents. Finally, future studies might usefully assess how other internal antecedents of the exploratory, transformative, and exploitative learning processes—such as firm structure and human resource practices—interact with the mechanism identified here in the development of a firm's AC. These studies could also incorporate multiple levels of analysis and examine other individual-level as well as organization-level variables (Volberda et al., 2010; Lewin et al., 2011).

## 6. Conclusion

This study has put forward the connection between the adoption of breadth and depth knowledge search strategies and the development of a firm's AC. It has shown the different breadth and depth search strategies required in each learning process: exploration, transformation and exploitation. Specifically, we suggest that in order to develop explorative learning it is necessary to establish as much relationships with external agents as possible. However, in the case of transformative learning, the focus should be in promoting the right number of deep collaborations. Finally, in the case of exploitative learning, firms should pay attention to establishing broad and deep connections with external agents, however they need to be cautious in this process as exceeding the number or the intensity of relations could affect negatively exploitative learning.

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## Annex

Questionaire items for absorptive capacity.

| *Could you please indicate your level of agreement with the following statements about your organization?* | | |
|---|---|---|
| Dimension | Item | Literature source |
| Recognize | X1: We frequently scan the environment for new technologies.<br>X2: We thoroughly observe technological trends.<br>X3: We observe in detail external sources of new technologies. | Arbussà and Coenders (2007), Jansen et al. (2005) and Szulanski (1996) |
| Assimilate | X4: We periodically organize special meetings with external partners to acquire new technologies.<br>X5: Employees regularly approach external institutions to acquire technological knowledge.<br>X6: We often transfer technological knowledge to our firm in response to technology acquisition opportunities. | |
| Maintain | X7: We thoroughly maintain relevant knowledge over time.<br>X8: Employees store technological knowledge for future reference.<br>X9: We communicate relevant knowledge across the units of our firm. | Jansen et al. (2005), Marsh and Stock (2006) and Smith et al. (2005) |
| Reactivate | X10: When recognizing a business opportunity, we can quickly rely on our existing technological knowledge.<br>X11: We quickly analyze and interpret changing market demands for our technologies.<br>X12: New opportunities to serve our customers with existing technologies are quickly understood. | Garud and Nayyar (1994), Jansen et al. (2005) and Marsh and Stock (2006) |
| Transmute | X13: We are proficient in transforming technological knowledge into new products.<br>X14: We regularly match new technologies with ideas for new products.<br>X15: We quickly recognize the usefulness of new technological knowledge for existing knowledge. | Jansen et al. (2005), Smith et al. (2005) and Todorova and Durisin (2007) |
| Apply | X16: We regularly apply technologies in new products.<br>X17: We constantly consider how to better exploit technologies.<br>X18: It is well known who can best exploit new technologies inside our firm. | Jansen et al. (2005), Smith et al. (2005) and Szulanski (1996) |

Questionaire items for external knowledge sources for innovation.

| *Please indicate which of the following sources of information your organization has used to innovate, and assess their level of importance.* | |
|---|---|
| Item | Literature source |
| X19: Other organizations within the business group<br>X20: Competitors and other enterprises from the same industry<br>X21: Suppliers of equipment, materials, components or software | Chen et al. (2011) and Murovec and Prodan (2009) |

X22: Clients or customers
X23: Consultants
X24: Laboratories or R&D companies
X25: Universities or other higher education institutes
X26: Government or private non-profit research institutes

Questionnaire items for turbulence.

*Indicate your degree of agreement with the following statements about your company*

| Item | Literature source |
|---|---|
| The technology in our industry is changing rapidly | Jaworski and Kohli (1993) |
| Technological developments in our industry are fairly minor (REVERSED) | |
| A large number of new product ideas have been made possible through technological breakthroughs in our industry | |
| New customers tend to have product-related needs that are different from those of our existing customers | |

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