Technological innovation typologies and open innovation in SMEs: Beyond internal and external sources of knowledge

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Abstract

SME inbound open innovation has primarily received attention for new product development, overlooking the fact that SMEs may also pursue process or, simultaneously, product and process innovation. We posit that different technological innovation typologies (product vs process) are related to distinct search strategies. Focusing on 3,867 innovative SMEs, results indicate that inbound open innovation is not only related to internal resources of innovation but also to the type of technological innovation chosen by firms. Our results disentangle a rather more complex and comprehensive view of SME inbound open innovation that prevents the fragmentation of results. It is not just about being more or less innovative, but about how SMEs innovate differently, developing distinct internal and external activities.

1. Introduction.

The topic of SME open innovation is well-studied (e.g. Brunswicker and Vanhaverbeke, 2015; Chen et al., 2016; de Marco et al., 2020; Kapetaniou and Lee, 2019; Leckel et al., 2020; Parida et al., 2012; Radicic and Pugh, 2017; Radziwon and Bogers, 2019; Verbano et al., 2015). In this present study we focus on inbound open innovation or search strategy where literature, so far has not connected it to the type of innovation pursued by SMEs. In fact, SME search strategy has not distinguished between product, or process innovation. Rather, literature is focused primarily on product innovation, or just monitoring the SME type of innovation (Brunswicker and Vanhaverbeke, 2015; de Marco et al., 2020; Kapetaniou and Lee, 2019; Maes and Sels, 2014; Parida et al., 2012; Spithoven et al., 2013; van de Vrande et al., 2009). This blind spot tacitly suggests that SME inbound open innovation only centers around product development, or rather, that the specific type of technological innovation developed does not matter, neglecting the understanding of different typologies of in- novation pursued by SMEs. SME heterogeneity, however, is a fact (Ortega-Argilés et al., 2009). SMEs are even said to be process-oriented, especially those in low-value added segments or low-tech industries (e.g. Heidenreich, 2009). In line with this chain of thought, our study builds upon (Chesbrough and Bogers, 2014), which points out that re- search on SME open innovation needs to go beyond R&D and product development in order to understand SME innovation comprehensively and, especially, inbound open innovation. Therefore, we explore the relationship between typologies of technological innovation and in- bound open innovation in SMEs.

Specifically, this research investigates how different types of technological innovation are connected to a diverse set of innovation strategies configured by different internal and external sources of knowledge in SMEs. The focus on both internal and external sources is necessary because SMEs' external knowledge sourcing or inbound open innovation, to a certain extent, depends on internal capabilities (Brunswicker and Vanhaverbeke, 2015; Cohen and Levinthal, 1990; Volberda et al., 2010): literature on SME open innovation has evi- denced that firms coherently align both sources of knowledge, there- fore, we consider internal capabilities to be related to search strategies (e.g. Brunswicker and Vanhaverbeke, 2015; Hervas-Oliver et al., 2014; Laursen and Salter, 2006). Our rationale is as follows.

We argue that depending on a firm's capabilities, its position in its value chain, its industry, strategy and market conditions (competition, location, regulations, changes in consumers, etc.), among other factors, SMEs formally or informally decide where to orientate innovation efforts. These efforts, or investments, turn into specific activities that are internally developed (like R&D) or externally accessed (e.g. knowledge about new machinery from equipment suppliers or a new formula li- censed by a contract with a university). We assume that the typology of innovation is planned by firms and each type determines a different innovation strategy. We define innovation strategy as the strategic choices made by firms for the innovation process in the sense of (Nelson and Winter, 1982), developing certain routines or capabilities to innovate. We argue, therefore, that inbound open innovation is not only related to internal resources of innovation (e.g. Brunswicker and Vanhaverbeke, 2015; Radziwon and Bogers, 2019) but to the typology of technological innovation chosen by firms, which permits the dis- tinction between different types of innovation patterns and performance (Bogliacino and Pianta, 2010; Evangelista and Vezzani, 2010). External sourcing or inbound open innovation is, therefore, contingent on the specific type of innovation pursued by SMEs. Put differently, the type of technological innovation chosen (product vs process) will be related to a specific innovation strategy or a combination of internal and external sources of knowledge for SME innovation.

As regards theory, this study also provides a framework based on capabilities with which to understand the alignment of each technological innovation with the integration of different sources of knowledge, both internal and external. These combinations generate interrelation- ships and synergies (e.g. Porter, 1996; Siggelkow, 2001) from joint integration of different sources of knowledge, using the resource-based view of the firm (RBV) (e.g. Barney, 1996) and dynamic capabilities perspective (Peteraf et al., 2013; Teece and Leih, 2016; Teece et al., 1997), in order to explain the building up of sets of complex configurations of internal and external knowledge related to technological innovations.

This study's goal consists of analyzing how different search strategies, or inbound open innovation sources, are associated with techno- logical innovation strategies (product or process innovation). In doing so, this study answers a key research question: in SMEs, how important are internal and external sources of innovation for each technological innovation? The study contributes to the SME open innovation literature (e.g. Brunswicker and Vanhaverbeke, 2015; de Marco et al., 2020; Parida et al., 2012; Radziwon and Bogers, 2019) by showing, empirically, a set of different combinations of technological innovations and their associated internal and external sources of knowledge and thus disentangling a rather more comprehensive view of SME inbound open innovation that prevents the fragmentation of results. In addition, this study also offers another supplementary contribution by providing a capability-based framework from which to interpret the combinations of internal and external sources of knowledge.

Empirically speaking, this paper addresses information from 3867 SMEs over a three-year period, in the 2004–2006 wave of the Spanish Community of Innovation Survey (CIS). Results point out that it is not about being more or less innovative: it is about how SMEs innovate differently and how they develop different types of internal and ex- ternal activities.

The structure of the paper is as follows. Section two presents a framework from which to address SME open innovation, developing hypotheses. Then, Section three shows the empirical design, and Section four presents the findings and discusses results, and is after- wards followed in Section five by conclusions and suggestions for future lines of research.

2. Open innovation and technological innovation in SMEs.

2.1. Open innovation: an introduction.

Innovation and its determinants have been extensively studied at the organizational level of analysis through a range of different perspectives, such as organizational learning (Cohen and Levinthal, 1990, 1989), the knowledge-based view (Kogut and Zander, 2009) or technology strategy (Henderson and Clark, 1990; Utterback and Abernathy, 1975), among others. Seminal works such as those by Allen (1977), Allen and Cohen (1969), Kline and Rosenberg (1986), Pavitt (1984),

Rothwell (1974), Teece (1986), von Hippel (1988), among others, claimed that external linkages and sources of knowledge play an important role in innovation. Such works gradually shifted scholars' conversations on innovation toward firms' boundary-spanning search strategies[1], and thus served to crystallize the key importance of external sources of knowledge to a firm's performance (e.g. Dyer and Singh, 1998).

More recently, the idea of search strategies involving the use of a wide range of external actors and sources was more popularized by Chesbrough (2003) reference to open innovation and the observation that many firms had shifted to the practice of accessing to external knowledge from a diverse typology of sources and actors that convey different knowledge to support the innovation process. But even previous to Chesbrough's work, the relevance for innovation of openness and the search behavior of firms had already received ample attention by management and innovation scholars (Arora and Gambardella, 1990; Veugelers and Cassiman, 1999).

A firm's external knowledge sourcing indicates how firms build their search strategy in order to access different types of external (to the firm) knowledge, such as that obtained from suppliers, science or technology customers or consultants (e.g. Laursen and Salter, 2006). As empirically evidenced in literature, SMEs present a propensity to networking but less than larger firms do, due to their weak internal innovation cap- abilities and a poor absorptive capacity[2] (Rammer et al., 2009). This phenomenon constitutes an interesting paradox, as SMEs need much more access to external knowledge because of their weak in-house capabilities, but larger firms

[1] Freeman (1987), Lundvall (1992) and Nelson (1993) started to framework the idea of openness within national systems of innovation.

[2] Spithoven et al. (2013) found slightly different arguments by comparing SMEs and larger firms.

generally possess more resources to connect and absorb, as well as R&D capabilities that determine absorptive capacity in the sense of Cohen and Levinthal (1990).

2.2. A capability-based framework.

The RBV (resource-based view of the firm, Barney, 1996) and the dynamic capabilities (Peteraf et al., 2013; Teece and Leih, 2016; Teece et al., 1997) constitute the basis for a framework to understand how firms create and configure internal and external activities to build their capabilities to innovate. The specific sequential learning process for external sources starts with the exploration or identification for firms of valuable external knowledge in order to access them. Then, the knowledge is assimilated and transformed in order to be part of other internal resources to innovate, reinforcing existing knowledge and re- configuring innovation capabilities. That assimilated knowledge, which has been used for the reconfiguration of capabilities, is eventually exploited to produce new commercial outputs or even new processes that are going to improve existing offerings. External oriented knowledge builds on internal capabilities, directly created by a firm's expertise, routines, market knowledge, technology and organization systems, among many others (e.g. Cohen and Levinthal, 1990; Lane et al., 2006; Volberda et al., 2010).

Interrelationships and synergies created from joint integration of different sources of knowledge, internal and external, build up cap- abilities, as the RBV and dynamic capabilities suggest, as does technology strategy literature. As stated by Stieglitz and Heine (2007), the joint adoption and integration of different sources of knowledge, such as internal and external, facilitates the creation of synergies through the cross-fertilization of diverse assets and routines that permit the construction of a complex and consistent system of interrelated activities which mutually complement and reinforce one another for the purpose of improving and strengthening innovation capability. The integration of a range of internal and external processes, assets, operations, in- formation, knowledge and other potential sources of advantage deriving from the integration of internal and external sources of knowledge, configure and recombine innovation capabilities, building up a set of complex combinations of internal and external knowledge that underpin a firm's innovation capability and competitive advantage. To sum up, developing unique capabilities to innovate does not originate only from the development of internal and external resources, but from integrating them, forming sets of complex interrelationships that lead to superior innovation strategies (Ennen and Richter, 2010; Peteraf et al., 2013; Rivkin, 2000; Siggelkow, 2001; Teece and Leih, 2016). All in all, the combination of internal and external sources of knowledge, as a reinforcing mechanism, configures the innovation capability that underpins a given technological innovation strategy, whether it be product or process innovation.

2.3. Typologies of technological innovation and their innovation strategies.

As Ortega-Argilés et al. (2009) point out, addressing SMEs requires consideration of a high heterogeneity of innovative strategies in SMEs, ranging from R&D performers to those that are non-R&D-based, being more focused on networking and poor internal capabilities. Similarly, other studies also find heterogeneity of internal and external sources of knowledge among SMEs (Brunswicker and Vanhaverbeke, 2015; Spithoven et al., 2012). This SME heterogeneity, however, is not related to technological innovation in literature.

The distinction between technological product and process orientations, as major technological innovative outputs, are well de- scribed in the literature, even though the understanding of their respective external and internal sources of knowledge, in the case of SMEs, are under-researched. In this context, Clausen et al. (2012) empirically address that distinction between product and process innovation strategy. Product innovation, on the one hand, is found to be persistent and strongly associated with R&D activity as a long term oriented purpose; high fixed costs involved (e.g. supporting lab equipment, patent portfolio, etc.) and the necessary large innovation capacity (minimum threshold) for supporting a R&D based investment require the latter to be a long-term oriented and rather persistent process (e.g. Parisi et al., 2006). On the other hand, process-oriented activities are less formalized but based on experience and learning-by-doing. Process innovation is more short-term oriented than the product, requires less scientific infrastructure and, therefore, requires less commitment of resources (e.g. lab equipment, infrastructure, etc.) being really important in less technological-intensive sectors that are not driven by R&D activities. Similarly, Evangelista and Vezzani (2010) posit that the distinction between product and process innovation is still an effective way to identify the "dominant" type of strategy pursued by firms in different industries and technological regimes (Crespi and Pianta, 2008; Pavitt, 1984), showing different innovative patterns and performance (Bogliacino and Pianta, 2010).

SMEs in low-tech industries, focused on non-R&D and/or positioned in low-valued added parts of their value system (see Heidenreich, 2009; Rammer et al., 2009) usually show poor internal innovation cap- abilities. These firms are non-R&D performers that primarily develop process-oriented innovations (e.g. Barge-Gil et al., 2011; Heidenreich, 2009; Rammer et al., 2009), working through problem- solving, experimentation on the shop floor, reverse engineering and other activities that substitute for R&D. As regards networking, they rely mostly on acquiring embodied knowledge (machinery, equipment, etc.) and knowledge transfer by suppliers. They also show a poor absorptive capacity that limits their networking to some specific value- chain actors such as suppliers and furthermore are limited to the supply-chain (Heidenreich, 2009; Hervas-Oliver et al., 2020; Rammer et al., 2009; Spithoven et al., 2012). This process-oriented pattern is related to extensive collaboration and interaction, using intensively external sources of knowledge from suppliers and embodied technology, as well as presenting poor internal innovation capabilities. Therefore, we state the following hypothesis:

Hypothesis 1. Process-oriented SME innovation strategy is built around embodied knowledge and supply-chain sources, where suppliers' knowledge is prominent and scientific sources and activities scarce.

As regards product innovation, Grimpe and Sofka (2009) pointed out that R&D is directly related to product innovation development when supported by knowledge from customers and interactions with scientific sources such as universities, a result coincident with that of Parida et al. (2012), both studies being based on product innovators. Similarly, Spithoven et al. (2012) also found the positive influence of R&D on firm innovativeness for developing new products, even though they did not distinguish types of external sourcing. Other additional studies have also evidenced that SMEs can be oriented to R&D (Hölzl, 2009; Stam and Wennberg, 2009); for example Kapetaniou and Lee (2019) relate product development to R&D and a wide range (breadth) of external innovation sources, including value-chain or industry actors, whether science based or otherwise, showing similar results to Parida et al. (2012). Consequently, we expect that SMEs oriented to product innovation choose to invest in in-house R&D activities so as to innovate and thus build up a high and rich absorptive capacity, which enables access to a wide scope of networking that includes a high diversity of supply-chain or industry- and science-based actors. Similarly, and bearing in mind the product-oriented firms in (Clausen et al., 2012), those advanced and innovative SMEs focus on product development, present higher absorptive capacity, accessing a myriad of collaborations or external sources of knowledge from value chain as well as scientific ones, showing a high extent of openness. These pro- duct-oriented SMEs that undertake R&D present intensive internal in- novation capabilities that are combined with search strategies from market and scientific sources. Networking for this group is more diverse and less limited than the process-innovators previously referred to. Therefore, we state the second hypothesis as follows:

Hypothesis 2. Product-oriented SME innovation strategy is built around R&D, science and supply-chain sources, where market knowledge is prominent.

3. Method: population, data and variables

Data was drawn from the Spanish (Eurostat) Community Innovation Survey for 2006. The Community Innovation Survey (CIS) is extensively used in the UK, France, Spain, Italy or Belgium, among other countries (e.g. Battisti and Stoneman, 2010; Grimpe and Sofka, 2009; Laursen and Salter, 2006), especially by SMEs (Heidenreich, 2009; Spithoven et al., 2012). The CIS is based on a standard core questionnaire developed by the European Commission (Eurostat) and Member States to ensure international comparability. CIS data offer a direct measure of success in commercializing innovations for a broad range of industries that other sources of information do not capture (Leiponen and Helfat, 2010). CIS questionnaires are administered by national statistical offices. In Spain, the INE (National Institute of Statistics) administers data every year, producing the "Technological In- novation Survey" that is then transferred to Eurostat as Spanish CIS data. Firms are in fact asked about the type of innovation introduced over the three-year period covered by the survey and the specific in- novation activities carried out in the same period (innovation effects, expenditures, hampering factors, among many others), all of which are associated with innovation. A key strength of CIS is that it collects data from very large samples of firms, representative of all manufacturing and service industries across Europe. CIS in Spain is a type of survey with an annual basis; the population scope covers agricultural, industrial, construction and services companies with 10 or more employees, whose main economic activity corresponds to sections A to N, P (excluding branch 854), Q, R, and S (excluding branch 94) of CNAE- 2009; the geographical scope applies to the entire national territory of Spain; the reference period is the year before that in which the survey was conducted, although the variables related to the innovations implemented by the companies refer to the three-year period preceding the year in which the survey was carried out in order to facilitate international comparability; the sample size presents as a threshold more than 40,000 companies; the collection method is a mixed system that includes Internet collection (CAWI) as well as by mail with significant telephone support from interviewers. More information about sampling and data treatment at INE[3].

In total, 3867 SMEs declared themselves to be technological innovators in the studied (2004–06) period. Our empirical analysis covers the effects of introducing innovative activities by

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[3] https://www.ine.es/dyngs/INEbase/en/operacion.htm?c=Estadistica_C&cid=1254736176755&menu=ultiDatos&idp=1254735576669

innovatively active firms (3867 firms) from which 1275 indicated the introduction of only product innovation (PURE_PRODUCT group) and 2592 declared having introduced only or solely process innovation (PURE_PROCESS group). These are the differing types of technological innovation (INNO_TYPE variable). See Table 1.

Insert Table 1 here.

As regards independent variables, the variable R&D_Internal captures a firm's in-house investment in research and development activities, while the variable BUY_TECH depicts the investment in the acquisition of machinery, equipment and advanced hardware or software aimed at the production of new or significantly improved products or processes. Following on from that, another variable that captures an investment or effort to innovate is TRAINING_SUPPORT, measuring the training of staff for innovation activities.

As other studies have indicated (e.g. Hervas-Oliver et al., 2020; Laursen and Salter, 2006), external sources of knowledge capture open innovation activity. Regarding external sourcing or search strategies, this present study operationalizes strategic types of (inbound) openness in SMEs. We focus on external knowledge sourcing over the last 3 years (2004–2006) as regular interactions (External Sources variables) with Customers, Suppliers, Consultants and Science-based agents (IN- FO_SCIENCE, Cronbach's Alpha, 0.81, is made up by adding Universities, Public Research Bodies and Research Centers; Info_University, Info_Public_Research and Info_CT[4]). Similarly to Laursen & Salter (2006) we code the main external source variables with 1 when the firm in question reports that it uses the source to a high or medium degree and 0 in the case of no or low use of the given external source. Afterwards, the sources are added (OPENNESS variable; Cronbach's Alpha of 0.7278) up so that each firm gets a score of 0 when no knowledge sources are used, while the firm gets the value of 4 when all knowledge sources are used. This variable shows the intensity (or dependency) of the differing agents of innovation and their flows of knowledge. As usual in such analyses, we include control variables, such as SIZE, measured as the total number of employees, and industry classification, measured using 2-digit NACE-93 industry classification as dummies (INDUSTRY_DUMMIES variable). Industries were identified based on the NACE2-digit classification. Our sample includes both manufacturing and service SMEs[5]. Internal consistency and scale reliability of different variables is offered in Table 1. See Table 1.

4. Methods and results

4.1. Descriptive and bivariate analysis

Table 2 shows the correlation matrix.

Insert Table 2 here.

In continuation, Table 3 shows the mean comparison graphically, with ANOVA tests, of the main variables across different innovation typologies. As observed in Table 3, where ANOVA tests

[4] In order to avoid multicollineality we decided to add them up into a single indicator, as in the Spanish questionnaire they do not differ substantially.

[5] For the sake of brevity, more available upon request. As regards the differences between manufacturing and service sectors, this study is grounded on an integration approach (Gallouj and Savona, 2009; Salter and Tether, 2006), assuming that both manufacturing and service sectors can be concurrently analysed, albeit while respecting certain key differences.

were per- formed, both sources of knowledge, internal and external, are significantly different for the two technological innovation groups: PURE_PRODUCT and PURE_PROCESS. In Table 3 important differences appear, indicating the different innovation strategy observed in each group of firms. As such, process-oriented SMEs (PURE_PROCESS) pre- sent the lowest values for R&D_Internal (mean 0.240) and Training_Support (mean 0.07), indicating a low internal development of innovation capabilities. On the other hand, these process-oriented SMEs account for the highest values in BUY_TECH (mean 0.494) and Sup- pliers (INFO_SUPPLIER, mean 0.61). This pattern is consistent with hypothesis 1 for the group of the process-oriented firms (PURE_- PROCESS). Furthermore, as observed in Table 3, the PURE_PRODUCT group of firms, presents the highest values in R&D_Internal (0.574 for product-oriented vs 0.240 for process-oriented), Customers (0.52 for product-oriented and 0.35 for process-oriented); then, Training_Support (0.08 for product-oriented and 0.07 for process-oriented), and Consultants (0.209 for product-oriented and 0.205 for process-oriented) show similar means, while Science (0.25 for product-oriented and 0.180 for process-oriented) is significantly higher for product innovators. On the other hand, Suppliers (0.61 for process-oriented vs 0.45 of product-oriented ones) and BUY_TECH (0.49 for process-oriented vs 0.08 for product ones) are significantly much lower than process-oriented ones. Both groups show a different approach to openness: product-oriented are more reliant on market sources (Customers vs Suppliers for process-oriented ones) and also access to scientific sources, the latter more intensively than process-oriented firms. To conclude the descriptive analysis, PURE_PRODUCT firms show the strongest internal innovation capabilities, while process-oriented ones are basically developing external sources limited to equipment and suppliers and poor in-house innovation capabilities. See Table 3.

Insert Table 3 here.

4.2. Econometric specification: logit analysis

After the above descriptive and bivariate analysis, in Table 4, we perform logit models in order to test hypotheses and answer the key research question: For SMEs, how important are internal and external sources of innovation for each technological innovation? Logit technique differs from the ANOVA tests because the latter indicate the re- lative strength or the value of the innovation drivers in each sub-sample (PURE_PRODUCT VS PURE_PROCESS groups). On the other hand, logit method accounts for the (internal and external) factors that explain the adoption of process innovation vs product innovation. Through logit technique we can observe much better how important the internal and external sources of knowledge are for predicting the adoption of each technological innovation. In particular, this technique allows us to see the probability that one source of innovation explains the adoption of each technological type in contrast to the non-adoption of the other, for the purpose of disentangling what specific combination of internal and external sources of knowledge is most predominant in each technological innovation type. See Table 4.

In Table 4, the logit model accounts for one specific group over the other (INNO_TYPE: Model 1 and 2, pure process vs pure product and Model 3 and 4 for pure product vs pure process). The specifications run very well, showing pseudo-R2 ranging from 0.23 (Model 2 and 4) to 0.255 (Model 1 and 3). See Table 4.

Insert Table 4 here

In Model 1, adopting process innovation (solely) vs product in- novation (solely), the key variables are R&D and BUY_TECH in a very interesting way. R&D accounts for −0.851 coefficient and BUY_TECH is represented by +2.11 coefficient, both statistically significant at $p<0.01$. The interpretation is clear: R&D is not a major driver for process innovation, it is rather a negative driver compared to choosing product innovation. In other words, R&D is both very important, as well as positive and significant at $p<0.01$ for choosing product innovation (reverse interpretation) vs process innovation. This result means that process-oriented innovative firms do not develop in-house R&D activities internally, or at least that these are not a major driver for developing process innovation. On the contrary, product-oriented, however, are driven by internal R&D activities and develop in-house capabilities to innovate. Training (non-significant) is not a driver to predict process innovation, compared to product, showing also the low level of in- house internal capabilities to innovate for process-oriented firms.

Next, BUY_TECH, the search for external sources of knowledge from equipment and machinery interpretation is also relevant in Model 1. It is a major driver, the one with the highest coefficient in Model 1 (+2.11, statistically significant at $p<0.01$), to predict process innovation versus product innovation, being also the strongest coefficient across all models and innovation typologies. The reverse also works, it is not a driver to predict the adoption of product innovation, vis-à-vis process innovation. This result means that acquiring equipment, as a source of external knowledge from equipment suppliers, is a major driver for process-oriented firms, indicating clearly that process-oriented ones do not develop in-house capabilities but are reliant on ex- ternal ones from embodied knowledge in equipment. The result corroborates, from a different perspective, the same insight gathered from the non-effect of R&D observed. On the other hand, for product-oriented innovators, equipment and embodied knowledge (BUY_TECH) is not an effective driver because product-oriented innovators develop in- house innovation capabilities, at least from R&D. Overall, the results clearly show how process-oriented firms show very distinct innovation strategies compared with product-oriented ones.

As regards other external sources of knowledge or inbound open innovation, in Model 1 we can observe that for process-oriented firms the most important external source derived the value chain is that from Suppliers (INFO_SUPPLIER, 0.708 at $p<0.01$), while Customers (Info_Customer) is negative and statistically significant (−0.521, $p<0.01$). The rest of the external sources to innovate are non- significant, where Science (Info_Science) also shows a negative relationship. This insight is crystal clear: suppliers are key for process, versus product, and customers are key for product versus process innovators. Also, science (Info_Science) does not work for pure process vs pure product. These results indicate that for process-oriented firms, suppliers are the core external source from the value chain and that those from the market (customers) or scientific ones are not relevant. In other words, the process innovators' collaboration pattern is primarily explained by and limited to embodied knowledge (BUY_TECH) and suppliers (INFO_SUPPLIER). The reverse is also true: product-oriented firms primarily prefer Customers and Scientific external sources. Therefore, in Model 2, the results are confirmed, albeit aggregating all external sources into the OPENNESS variable, which shows only a $p<0.1$ positive relationship.

On the contrary, considering Models 3 and 4, is equivalent. The product vs process logit exactly reveals the reverse results, confirming what Model 1 shows. Thus, in Model 3 R&D_Internal is positive and significant (+0.851 at $p<0.01$ for pure product vs process innovation), BUY_TECH is negative and significant (−2.11, at $p<0.01$), Suppliers are negative and significant at $p<0.01$ (−0.708) and Customer is positive at $p<0.01$ (+0.521): exactly similar coefficients but with different signs, confirming that which Model 1 anticipated. Model 4 (product vs process) also indicates that R&D is positive (0.951 at $p<0.01$) and BUY_TECH is negative (−2.102 at $p<0.01$), showing also a negative relationship between Openness and Product innovation (−0.0712), suggesting that product innovators are slightly less open than process ones, even though the effect is only significant at $p<0.1$. Overall, the interpretation of Model 1 and Model 3, for process vs product and vice-versa, respectively, present a very clear pattern for predicting each type of technological innovation. First of all, process innovation shows embodied technology (BUY_TECH) and suppliers as the predominant sources of innovation, presenting a poor contribution of R&D. These results are totally in coherence with literature, which pointed out that non-advance process-based SMEs invest poorly in R&D, and are in fact non-R&D innovators, and rely primarily on suppliers and external machinery (e.g. Heidenreich, 2009; Parisi et al., 2006; Rammer et al., 2009). Secondly, reverse interpretations from Model 3 fully coincide with those studies that have encountered that product development and R&D are very close and also driven by knowledge from the market (Customers) (Grimpe and Sofka, 2009; Hölzl, 2009; Kapetaniou and Lee, 2019; Parida et al., 2012; Parisi et al., 2006; Spithoven et al., 2012; Stam and Wennberg, 2009), albeit this study's results do not qualify for scientific sources (e.g. Universities).

In short, results clearly indicate that product-oriented and process- oriented innovators are made up of different internal activities and external sources of knowledge to innovate. Overall, process-oriented innovators are driven by poor internal capabilities represented by low R&D investments and an excessive dependence on knowledge from suppliers, primarily embodied in machinery and equipment, confirming the embodied hypothesis (e.g. Heidenreich, 2009). On the contrary, product innovation is related to R&D and market knowledge from customers, and not driven by embodied knowledge. Both groups show fairly similar openness, albeit based on distinct sources. See Table 4.

5. Conclusions

We focus on inbound open innovation or search strategy where literature, however, has not yet connected it to the type of innovation pursued by SMEs. This study's goal consists of analyzing how different internal and search strategies, or inbound open innovation sources, are associated with technological innovation strategies. This research al- lows us to answer the following research question: how important are internal and external sources of innovation for each type of technological innovation? A capability-based framework is developed in order to contextualize this study's argument with regards to 3867 SMEs.

This study's results confirm the two stated hypotheses, albeit with some minor changes. Process-oriented SMEs show non-R&D performance and a limited use of external sources primarily limited to embodied knowledge and suppliers (H1); product-oriented SMEs develop internal capabilities through R&D and primarily access knowledge from the market (Customers), not accessing embodied knowledge, vis-à-vis process-oriented innovators (H2). The results do not show that product innovators use intensively scientific sources like knowledge from universities, nor show more openness than process innovators. The results, however, point out that it is not about being more or less innovative but about SME heterogeneity. In fact, it is about how SMEs innovate differently and how they develop different types of internal and external innovation oriented activities.

This study contributes to the existing literature. Firstly, assuming SME heterogeneity (Hervas-Oliver et al., 2011; Ortega-Argilés et al., 2009), our study goes one step beyond and clarifies how different in- bound open innovation is for each type of technological innovator. In fact, our insights point out what type of internal and external sources matter and how much for each group of firms. Thus, our insights permit us to map the complexity of SME innovators. This in turn allows us to interpret and contextualize previous studies that did not distinguish types of innovators and overlooked the type of technological innovation pursued, producing fragmented evidence of the phenomenon. As such, when previous studies point out that SMEs can be oriented to R&D (e.g. Hölzl, 2009; Kapetaniou and Lee, 2019) and product innovation, it is perfectly coherent with other studies that posit that SMEs are primarily non-R&D innovators and process-oriented (Heidenreich, 2009; Rammer et al., 2009): all are correct, in as far as they consider each specific type of technological innovation and its innovation strategy.

Secondly, this study's contribution also presents a framework based on the idea that the integration of internal and external sources of knowledge creates combinations of activities that build up a firm's in- novation capabilities, utilizing the RBV and the dynamic capabilities perspective. The joint introduction of internal and external sources of knowledge forms synergistic and complex interrelationships difficult to imitate, contributing thus to improving a firm's competitive advantage, recognized in the RBV, producing an inimitable system that improves itself, and creating a unique configuration that sustains and develops SME innovation capabilities (Peteraf et al., 2013; Rivkin, 2000; Stieglitz and Heine, 2007).

Thirdly, this study provides insights for policymakers. In order to best capture innovation in SMEs, policymakers need to be aware of the differing typologies of innovators among SMEs: heterogeneity is the point! It is not about being more or less innovative, it is about how SMEs differently innovate, developing distinct internal and external activities. One-size-fits-all policies for stimulating SME innovation do not take into account the distinct array of innovation typologies and their associated innovation activities. Product and process innovation, separately, requires different tools and initiatives for each of its in- novation strategies. Overall, the specific activities, both internal and external, that can be successfully implemented by each group, are of great importance for policymakers. Product-oriented innovators that carry out R&D and rely on knowledge from markets, can be stimulated with R&D vouchers, funds to create an R&D department or activities for market intelligence, whereas equipment renewal may be useless. On the contrary, process-oriented innovators basically require equipment renewal to access embodied knowledge, while scientific-based incentives for R&D or access to scientific sources are useless due to their low in- ternal capabilities to innovate.

Fourthly, for scholars, the study of open innovation requires a more complete understanding of the complex taxonomy of SME heterogeneity, introducing innovation typologies. Thus, studying SMEs re- quires considering complex interrelationships existing among internal sources, as well as external ones and technological innovation typologies to framework specific arguments and rationales. The SME in- novation map from our results may provide a better orientation to pursue research questions more comprehensively, avoiding fragmentation and generalization of biased empirical designs. Put differently, SMEs should not be conceptualized or approached using a one-size-fits- all perspective, but recognizing their heterogeneity, as recent studies have just started to do (e.g. de Marco et al., 2020; Leckel et al., 2020). This paper is not without its limitations. First of all, the sample is limited to Spain. Besides, the results are also limited by the time span used (3-year period). For future studies, a more in-depth analysis of the differing typologies of innovation and innovation strategies in Europe should be carried out by specifically comparing more countries within Europe, thus evaluating the generalization of this study's results.

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TABLES

Table 1. Variables used for SME innovation strategies and types of innovation. Source: own

Dependent variables	Description	Codification
INNO_TYPE	Indicates the two innovation types: (1) PURE_PROCESS: Indicates that the enterprise has introduced a new or significantly improved method for the manufacture or production of goods or services, logistics systems or delivery or distribution methods for its supplies, goods or services or/and support activities for its processes, such as systems of maintenance or IT operations, of purchases or of accounting, being new or significantly improved *without* introducing any further new or significantly improved goods or services. (2) PURE_PRODUCT: Indicates that the enterprise has introduced new or significantly improved goods or services without the implementation of production processes, distribution methods or support activities for the goods and services that are new or provide a significant improvement	Two different 0–1 dummies
Independent variables	Description	Codification
R&D_Internal	Creative work carried out within the company in order to increase the volume of knowledge and its use for conceiving new or improved products and processes	Dummy 0–1
BUY_TECH	*Acquisition of machinery, equipment and advanced hardware or software* aimed at the production of new or significantly improved products or processes	Dummy 0–1
TRAINING_SUPPORT	Internal or external training of staff, specifically aimed at the development or introduction of new or significantly improved products or processes.	Dummy 0–1
EXTERNAL SOURCES: INFO_SUPPLIER INFO_CUSTOMER INFO_CONSULTANT INFO_SCIENCE	Importance of the suppliers (of equipment, material, components or software) information for innovation activities; Importance of customer information for innovation activities; Importance of consultant information for innovation activities; INFO_SCIENCE: Represents the following variables related to scientific information: INFO_UNIVERSITY: Importance of the Universities (or other centers of higher education) information for innovation activities	Dummy 0–1

	INFO_PUBLIC_RESEARCH: Importance of Public Research Bodies (or other centers of higher education) information for innovation activities INFO_CT: Importance of technological centers, bodies (or other centers of higher education) information for innovation activities. The importance of information of each source is measured in the questionnaire in a four-point scale: Not used = 0; Poor, value = 1; Medium, value = 2; High, value = 3. We assigned the 0 value to Not used or Poor, and the 1 value to a Medium or High as Laursen and Salter (2006)	
OPENNESS	Sum of the External Sources variables: INFO_SUPPLIER, INFO_CUSTOMER, INFO_ CONSULTANT, INFO_SCIENCE (Cronbach's Alpha: 0.7278)	Scale 0-4
Control variable	Description	Codification
SIZE	Annual average of full-time employees	Continuous (0–250)
INDUSTRY_DUMMIES	Industry_NACE_code Industry classification by NACE-93 (2-digits, 23 sectors), from 15 to 37	Dummy 0–1

Table 2. Correlation matrix.

	Variables	Mean	Std. Dev.	Min	Max	1	2	3	4	5	6	7
1	SIZE	49.52	47.16	1	249	1						
2	R&D_Internal	0.35	0.48	0	1	0.0633*	1					
3	BUY_TECH	0.36	0.48	0	1	−0.0657*	−0.2728*	1				
4	TRAINING_SUPPORT	0.07	0.26	0	1	0.0623*	0.0953*	0.0775*	1			
5	INFO_SUPPLIER	0.55	0.50	0	1	−0.0159	−0.0392*	0.1360*	0.0633*	1		
6	INFO_CLIENT	0.41	0.49	0	1	−0.0077	0.2469*	−0.0694*	0.0880*	0.2336*	1	
7	INFO_CONSULTANTS	0.21	0.40	0	1	0.0541*	0.1406*	−0.0142	0.0618*	0.1661*	0.2237*	1
8	INFO_SCIENCE	0.20	0.40	0	1	0.0683*	0.2717*	−0.1019*	0.0695*	0.0574*	0.1744*	0.3409*

∗ $p<0.01$.

Table 3. ANOVA tests across types of innovation and other variables.

Variables	Indicator	PURE_PROCESS	PURE_PRODUCT	F
R&D_Internal	Mean	0.24	0.57	470***
	S.d.	0.43	0.49	
BUY_TECH	Mean	0.49	0.08	747.7***
	S.d.	0.50	0.28	
TRAINING_SUPPORT	Mean	0.07	0.08	1.21
	S.d.	0.25	0.27	
INFO_SUPPLIER	Mean	0.61	0.45	91.24***
	S.d.	0.49	0.50	
INFO_CLIENT	Mean	0.35	0.52	94.54***
	S.d.	0.48	0.50	
INFO_CONSULTANT	Mean	0.20	0.21	0.07
	S.d.	0.40	0.41	
INFO_SCIENCE	Mean	0.18	0.25	25.79***
	S.d.	0.38	0.43	

∗∗∗ $p<0.01$

Table 4 Logit models to explain the probability of choosing each type of technological innovation vs other.

Models	(0) PURE PRODUCT (1) PURE PROCESS		(0) PURE PROCESS (1) PURE PRODUCT	
Variables	Model 1	Model 2	Model 3	Model 4
R&D_Internal	−0.851*** (0.090)	−0.972*** (0.088)	0.851*** (0.090)	0.972*** (0.088)
BUY_TECH	2.110*** (0.116)	2.150*** (0.115)	−2.110*** (0.116)	−2.150*** (0.115)
TRAINING_SUPPORT	−0.19 (0.166)	−0.207 (0.164)	0.19 (0.166)	0.207 (0.164)
INFO_SUPPLIER	0.708*** (0.0877)		−0.708*** (0.087)	
INFO_CUSTOMER	−0.521*** (0.090)		0.521*** (0.090)	
INFO_CONSULTANT	0.0951 (0.109)		−0.0951 (0.109)	
INFO_SCIENCE	−0.0608 (0.107)		0.0608 (0.107)	
OPENNESS		0.0712* (0.036)		−0.0712* (0.036)
SIZE	0.002** (0.001)	0.002** (0.001)	−0.002** (0.001)	−0.002** (0.001)
Industry Dummies	YES	YES	YES	YES
Intercept	1.282** (0.612)	1.263** 0.604	−1.282** 0.612	−1.263** 0.604
Observations	3860	3860	3860	3860
LR chi2	1251	1172	1251	1172
Prob>chi2	0.000	0.000	0.000	0.000
Pseudo R2	0.255	0.239	0.255	0.239

*** $p<0.01$; ** $p<0.05$; * $p<0.1$.