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Product innovation of domestic firms *versus* foreign MNE subsidiaries: The role of external knowledge sources

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A R T I C L E I N F O

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External R&D
Knowledge-based view
Inbound open innovation

A B S T R A C T

We build upon the knowledge-based view and the open innovation literature to examine product innovation of domestic firms relative to subsidiaries of foreign multinational enterprises, and the mechanisms that domestic firms could use to catch up to foreign subsidiaries for product innovation. We propose three external knowledge sources that will have a positive impact on product innovation, namely, R&D collaborations, inward technology licensing, and external R&D. We hypothesise that the effects would be greater for domestic firms than for foreign subsidiaries. We empirically test our hypotheses using panel data from Spain (2006–2016). We find that domestic firms introduce fewer product innovations than foreign subsidiaries, and that the external knowledge sources are effective mechanisms for domestic firms to reach, or outperform, foreign subsidiaries in terms of product innovation.

1. Introduction

Product innovation is defined as the introduction of a product which is new or significantly improved with respect to its characteristics or intended uses (Atalay et al., 2013). There is a large volume of research on this phenomenon in the extant literature. Most previous studies have examined product innovation from the perspective of subsidiaries of foreign multinational enterprises (MNEs) operating in host countries (Ambos et al., 2006; Ambos and Birkinshaw, 2010; Andersson et al., 2016; Cantwell, 2017; Mudambi et al., 2018; Tse et al., 2021). On the one hand, the literature argues that subsidiaries of foreign MNEs suffer from the liability of foreignness (Zaheer, 1995), which is defined as the costs that firms operating outside their home countries incur over and above those of local firms. The performance of foreign subsidiaries is lower because of competitive disadvantages and lower integration into local networks (Zaheer, 1995). On the other hand, there is a counterargument that subsidiaries of foreign MNEs have strong competitive advantages which compensate for the liability of foreignness. They use knowledge and resources transferred from parent firms and MNE internal networks, and/or develop new knowledge by accessing complementary resources from external actors in host countries (Birkinshaw, 2000; Rugman and Verbeke, 2001) (for a review, see Rugman et al. (2011)). This literature has enhanced our understanding of the product innovation of subsidiaries of foreign MNEs; however, the insights from these studies may not be transferable to domestic firms due to differences in characteristics between these two groups of firms. Consequently, our understanding of product innovation from the perspective of domestic firms is limited.

In this paper, we suggest that domestic firms – defined as firms without any foreign equity participation and no subsidiaries abroad – are just as important as foreign MNE subsidiaries for academic research on product innovation (Jiang and Stening, 2013). Domestic firms are deeply rooted in their home countries, and contribute to the development of entrepreneurship, innovation, employment, and overall economic growth (Tomizawa et al., 2020). In reality, domestic firms have to compete against other domestic firms and subsidiaries of foreign MNEs in offering products that can satisfy customers in highly competitive markets. However, they may have limited resources. They could face challenges in developing new products, because they tend to focus more on developing products for local customers, and generating sales from local markets (Mata and Freitas, 2012). Such local market orientation and local knowledge sourcing may limit their capacity for developing new products. Thus, it is important to study how domestic firms view the nature of product innovation as a source of competitiveness and how

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they can improve their innovativeness (Ireland and Webb, 2007; Jiang and Stening, 2013; Un, 2016; Un and Rodríguez, 2018).

Yet, there is a scarcity of comparative research on product innovation of domestic firms relative to subsidiaries of foreign MNEs and the mechanisms that domestic firms can use to enhance their product innovation. Differences in profiles between these two groups of firms may result in differences in product innovation; however, they may share one common belief that product innovation is important to the growth of the firm and its financial performance. According to McKinsey survey, >25 % of total revenue and profits of firms across industries come from the launch of new products (Buffoni et al., 2017). From the perspectives of firm managers, gaining a clear understanding of product innovation will be of strategic importance for their competitive position. From the point of view of policy makers, understanding how firms can improve their product innovation will gain useful insights, which inform policy making because innovation is considered one of the engines driving the growth and wealth of a country. Thus, a lack of comparative research constitutes a notable gap in the literature.

We examine the phenomenon of product innovation from the perspective of domestic firms. We intend to fill the research gap by addressing two central research questions:

1. Are product innovation outputs (measured by the number of new products introduced to markets) of domestic firms weaker than those of subsidiaries of foreign MNEs?
2. If so, what mechanisms can domestic firms use to improve their product innovation outputs?

We build upon the knowledge-based view (Grant, 2013; Kogut and Zander, 1992, 1993) and the open innovation literature (Chesbrough, 2003) for our theoretical development. The knowledge-based view emphasises that the firm is a repository of knowledge and highlights the importance of "knowledge integration", which is critical for innovation (Grant, 1996; Kogut and Zander, 1992; Winter, 1987). The open innovation literature maintains that "valuable ideas can come from inside or outside the company and can go to the market from inside or outside the company as well. This approach places external ideas and external paths to market on the same level of importance as that reserved for internal ideas and paths" (Chesbrough, 2003: 43). Prior research on product innovation shows that external knowledge can be valuable for firms, and the ability of firms to utilise external knowledge is important (Zahra and George, 2002).

We examine the product innovation of domestic firms and subsidiaries of foreign MNEs, and how domestic firms can improve their innovative capacity by using external sources of knowledge. We propose three inbound open innovation mechanisms, namely, research and development (R&D) collaborations, foreign inward technology licensing, and external R&D. We empirically test our hypotheses using a panel survey dataset of Spanish manufacturing firms for the period from 2006 to 2016. The findings confirm the relevance of these mechanisms.

We make three new contributions to the product innovation literature. First, our study provides a new theoretical insight with an integrative approach which is built upon the knowledge-based view and the open innovation literature. We suggest that product innovation reflects the firm's capability to integrate different sources of new inbound external knowledge besides the existing internal knowledge. Internal knowledge is captured in the firm's internal R&D investment and employees' qualification level, which also reflect the firm's absorption capacity, defined as the ability to identify, learn, integrate into the firm, transform, and utilise sources of knowledge that come from outside of the firm (Cohen and Levinthal, 1990; Minbaeva et al., 2014). When the firm invests in internal R&D and enhances staff qualifications, it will be able to fully appreciate the value of new external information and knowledge (Cohen and Levinthal, 1990; Veugelers, 1997). In this study, we focus on external knowledge sources from three specific mechanisms of open innovation, especially R&D collaborations, inward technology licensing, and external R&D as explanatory variables whereas internal R&D and highly qualified employees are control variables. We adopt a novel empirical approach, in which we examine product innovation of domestic firms and subsidiaries of foreign MNEs which are two completely different firm profiles. The contribution of our study is further augmented by the open innovation approach whereby we analyse the effects of external knowledge sources on the product innovation for these two groups of firms. We find that these three external knowledge sources help domestic firms to catch up and outperform subsidiaries of foreign MNEs in product innovation. Our study enriches the knowledge-based view (Kogut and Zander, 1992, 1993) which emphasises the theoretical importance of the concept of combinative capability. Our study shows that domestic firms adopt an integrative approach in utilising different sources of external knowledge to enhance their product innovation beyond internal R&D.

Second, we make an original empirical contribution by comparing product innovation of subsidiaries of foreign MNEs and domestic firms. To the best of our knowledge, there is a scarcity of this type of comparative research in the extant literature (Un and Cuervo-Cazurra, 2008). We provide direct empirical evidence of the large differences in product innovation between subsidiaries of foreign MNEs and domestic firms. We find that domestic firms introduce fewer new products than subsidiaries of foreign MNEs. MNE foreign subsidiaries access knowledge and technologies transferred from their parent firms and other fellow subsidiaries and thus introduce more new products. More importantly, our study goes beyond the comparison by focusing our efforts on identifying three mechanisms which are effective for domestic firms to improve their innovativeness and overcome the innovative challenges from subsidiaries of foreign MNEs.

Third, our empirical approach to simultaneously examine the impacts of three different external knowledge sources of open innovation on product innovation of domestic firms and subsidiaries of foreign MNEs is original. We find that open innovation is beneficial for effective and efficient access to new and often complementary knowledge, especially for domestic firms (Chesbrough, 2003). We adopt an integrative perspective in examining the phenomenon in its entirety. Our approach differs from previous studies which tend to examine separately one particular external knowledge source in a piecemeal manner rather than examining various external open innovation sources in a systematic and integral manner, as we attempt to do here.

2. Hypotheses development

2.1. Domestic firms and product innovation

The product innovation literature documents that domestic firms can proactively build the capabilities and knowledge required for innovation. They can independently generate internal knowledge, for example, through their own internal R&D investment. Internal knowledge is important; however, it may be insufficient for innovation as firms cannot possess or generate all the knowledge required to innovate. They must source, find, explore, and learn new knowledge from external sources. They also need to use and integrate different knowledge sources as this approach is critical for innovation (Michailova and Zhan, 2015).

Building upon the innovation literature, we argue that domestic firms introduce fewer product innovations relative to subsidiaries of foreign MNEs for the following reasons:

First, domestic firms tend to focus on local markets by developing an in-depth understanding of domestic market characteristics, needs and preferences of local customers, and the capabilities of local competitors (Mata and Freitas, 2012). Previous studies show that domestic firms generate the majority of their sales in domestic markets. Some of them may engage in exports; however, exports account for a much smaller share of their total sales (Almodóvar, 2011; Beleska-Spasova and Glaister, 2009). Local market orientation may put a limit on their ability to identify and use global sources of knowledge for product innovation.

Furthermore, they do not have a network of subsidiaries in other countries to acquire and utilise knowledge of product innovations developed elsewhere. As such, their access to global knowledge is limited, which constrains their product innovation.

Second, local market orientation may not motivate domestic firms to look beyond their home country's markets. All resources and attention are geared towards successfully competing in local markets. Consequently, this approach may have negative impacts on product innovation (Un and Cuervo-Cazurra, 2008). In contrast, subsidiaries are a part of the MNE internal network whereby knowledge can be created by both the parent firms and foreign subsidiaries (Rugman and Verbeke, 2001). There is coordination to create, transfer, and share knowledge (Mudambi et al., 2014) (for a review, see Scott-Kennel and Giroud (2015)). A number of subsidiaries may be assigned to engage in either developing new products or adapting products, which are driven by the needs of customers in highly competitive international markets (Afuah, 1998; Artz et al., 2010; Cantwell and Mudambi, 2005; Tether, 2002; Wei and Nguyen, 2020). Others are assigned to be R&D subsidiaries, which focus on creating knowledge that is new to the world and can be used within the MNE network (Achcaoucaou et al., 2017; Frost et al., 2002; Hannigan et al., 2015). This process enables subsidiaries to learn, access, and utilise the global knowledge base and combines it with local knowledge for product development (Gupta and Govindarajan, 2002).

Third, domestic firms are less exposed to international markets, international customers, and broader international business environments in their daily operations. In contrast, subsidiaries of foreign MNEs interact with parent firms and fellow subsidiaries for the coordination of activities and exchange of information and knowledge. These interactions enable focal subsidiaries to learn from their parent firms and other subsidiaries, which is useful for product innovation (Michailova and Zhan, 2015; Minbaeva et al., 2014; Rugman and Verbeke, 2001).

Finally, domestic firms do not have a network of foreign subsidiaries, and thus their sourcing, acquisition, and utilisation of external knowledge is less effective (Kostova and Roth, 2002). They are also constrained in searching for external knowledge and integrating internal knowledge with external knowledge because they are less aware of knowledge and ideas from other countries (Amabile, 1983). In contrast, subsidiaries have access to the knowledge base of their parent firms as well as those of their fellow subsidiaries. Innovations which are developed elsewhere in the MNE internal network can be used by subsidiaries in host countries (Un, 2011). Furthermore, foreign subsidiaries also actively engage in developing new knowledge, resources, and capabilities, which are known as subsidiary-specific advantages (Rugman and Verbeke, 2001). These are critical to be competitive in host markets. Almeida and Phene (2004) found that foreign subsidiaries were able to develop knowledge advantages through two complementary sources, namely internal (parent company and sister subsidiaries) leveraging and integration of knowledge and external learning from the host market.

Building upon the extant theoretical and empirical literature, we argue that domestic firms are likely to introduce fewer product innovations than subsidiaries of foreign MNEs. Thus, we predict the following:

Hypothesis 1. On average, domestic firms have a lower level of product innovation than subsidiaries of foreign MNEs operating in the same country.

2.2. Identifying mechanisms for domestic firms to improve product innovation

2.2.1. R&D collaborations

We build upon the open innovation literature to identify potential inbound open innovation mechanisms which may enable domestic firms to become more innovative (Bianchi et al., 2016; Hervas-Oliver et al., 2021; Sikimic et al., 2016). The underlying premise of the open innovation literature is that firms should use not only internal ideas and knowledge but also external ideas, knowledge, technologies and patents to accelerate their innovative outcomes (Chesbrough et al., 2006). External information and knowledge differ from the existing knowledge base of the firm, which may lower the risk of familiarity traps.

Firms establish relationships with other external partners (customers, suppliers, competitors, universities, research institutes, *etc.*) to access complementary knowledge and benefit from the effects of interactive processes (Kafouros et al., 2020; Ramayah et al., 2020). Un and Rodríguez (2018) suggested that R&D collaborations facilitate firms' product innovation because such partnerships provide incentives and mechanisms for creation, transfer, integration, and combination of knowledge among partners. Firms and external partners have incentives to collaborate to transfer and integrate knowledge for mutual benefits. R&D collaborations also facilitate partners' engagement in employee exchanges (Takeishi, 2002). This is critically important for innovation because tacit knowledge is embedded in the minds of employees in addition to explicit knowledge documented in company manuals, policies, processes, and procedures. R&D collaborations are designed to increase the knowledge base for partners since they facilitate the transfer and combination of internal and external knowledge sources for product innovation. Such collaborations are less costly than acquiring other firms, but they can be effective in facilitating innovation in both domestic firms and external partners.

The benefits of R&D collaboration may be different between subsidiaries of foreign MNEs and domestic firms. In the case of subsidiaries of foreign MNEs, they have a higher degree of global knowledge than domestic firms because they are integrated into the MNE networks with business activities in multiple countries and utilise global knowledge. They introduce new products which have been developed by their parent firms and/or other subsidiaries and then make necessary adaptions (if required) to local markets. In this way, they can leverage the internalisation benefit of being a part of the MNE corporate network and reduce the need for R&D collaborations with external partners when developing new products (Buckley and Casson, 2020; Buckley and Casson, 1976; Rugman, 1981).

Furthermore, subsidiaries of foreign MNEs are assigned specific roles (Bartlett and Ghoshal, 1989; Rugman et al., 2011) and mandates (Birkinshaw, 1996). For example, manufacturing subsidiaries focus on production activities and exploiting the extant bundles of firm-specific advantages transferred from their parent firms rather than performing R&D activities, exploring new knowledge, and developing new products. R&D subsidiaries are mandated with competence creation (Cantwell and Mudambi, 2005). This structured and systematic approach helps MNEs avoid duplication of resources and efforts in R&D because R&D is highly costly and risky, whereas the outcome is uncertain (for a survey, see Hall and Lerner (2010)).

In contrast, domestic firms have more in-depth knowledge of local market conditions, competitors, suppliers, and customers than subsidiaries of foreign MNEs. They develop business models and products which satisfy the preferences of local consumers and accumulate knowledge to deal with local institutions, norms and regulations (Almodóvar and Rugman, 2015; Un and Rodríguez, 2018). They become insiders of local networks which enable them to develop new products that are highly responsive to local markets (Un, 2016).

However, domestic firms may lack global knowledge due to their predominant focus on local markets. They use R&D collaborations with external partners as a mechanism to access external knowledge because external partners may have more universal knowledge. External knowledge will complement internal knowledge and facilitate domestic firms to enhance their product innovation. These collaborations are helpful for domestic firms to upgrade their knowledge base, which is relevant for product development (Caloghirou et al., 2021; Perri et al., 2017). Domestic firms can combine their understanding of local market conditions and external knowledge to create novel and locally adapted products (Un and Rodríguez, 2018). External partners can provide inputs and understanding of a variety of situations which can generate new applications of inputs (Un and Asakawa, 2015) and alternative approaches and adaptations for new product development. Thus, we predict that R&D collaborations have more positive impacts on domestic firms than on subsidiaries of foreign MNEs.

Hypothesis 2. R&D collaboration agreements have more positive effects on the development of product innovation, in terms of the number of new products, for domestic firms than for subsidiaries of foreign MNEs operating in the same country.

2.2.2. *Inward technology licensing*

Prior research has considered inward technology licensing as a source of knowledge exploration (Somaya et al., 2011) because it allows firms to source external technology (Lee et al., 2017). We focus on inward technology licensing in which a firm purchases the rights to use a patented technology generated by a foreign company. It might also be part of a resource creation method which develops new technologies and/or new products (Bianchi et al., 2016; Sikimic et al., 2016).

First, buying foreign technology and patents facilitates domestic firms' access to new technology, new solutions, and new ways of developing products. They acquire new knowledge and improve their extant knowledge base for product innovation. They can benefit from new and different technologies from foreign countries, which can be used in domestic markets to innovate products. Although some of these alternatives may not be innovative and new in other overseas markets because competitors may have already implemented them, they may still be innovative for domestic markets. This is referred to as cross-border imitation and innovation (Westney, 1987).

Second, inward technology licensing can provide domestic firms with different technological ideas, solutions, and ways of developing new products. In this way, domestic firms can gain an understanding of practices and products in other countries, which can be used to innovate products for domestic markets (Almodóvar et al., 2021).

Third, domestic firms can gain new insights from interacting with foreign licensors and become more aware of new ideas and solutions which can be used to innovate products. Licensors may provide domestic firms with ideas from business partners abroad as they develop products in foreign countries. Some of these ideas can be incorporated into the product development of domestic firms and become innovations in local markets (Un, 2016).

This baseline argument for inward technology licensing and knowledge diffusion is extended with the idea that domestic firms may benefit more from this inward licensing than subsidiaries of foreign MNEs. Domestic firms can enhance their positions in the markets by providing continuously innovative products using foreign technology reactively.

In contrast, subsidiaries of foreign MNEs already have access to foreign technology, resources, and knowledge from the parent MNE's network (Bartlett and Ghoshal, 1989; Ferraris et al., 2020; Ghoshal and Bartlett, 1990; Michailova and Zhan, 2015). When subsidiaries of foreign MNEs are assigned to serve domestic markets (Ghoshal and Bartlett, 1986), they use knowledge transferred from their parent firms and other fellow subsidiaries. Consequently, inward technology licensing may not have a significant impact on subsidiaries of foreign MNEs as much as it does on domestic firms.

Subsidiaries of foreign MNEs may benefit less from inward technology licensing because they may have already accessed such knowledge due to the multinational nature of their parent firms (Hobday and Rush, 2007; Kafouros et al., 2022). Subsidiaries of foreign MNEs may have already been exposed to these ideas and solutions. Thus, the impact of inward technology licensing may be less for subsidiaries of foreign MNEs than for domestic firms. Thus, we propose the following hypothesis:

Hypothesis 3. Inward technology licensing has more positive effects on the development of product innovation, in terms of the number of new products, for domestic firms than for subsidiaries of foreign MNEs operating in the same country.

2.2.3. *External R&D*

External R&D refers to R&D and creative work which is performed by other firms (UNESCO, 2020). External R&D facilitates domestic firms to access technology developed elsewhere (Berchicci, 2013; Mowery, 1990; Niosi, 1999). External R&D enables domestic firms to acquire new knowledge while managing risk and is thereby an attractive source of renewal (Keil, 2002). External R&D also helps domestic firms access knowledge from international sources for product innovation (Aiello et al., 2021; Nonaka and Takeuchi, 1995).

Domestic firms can use external R&D to overcome the financial constraints of their in-house R&D budgets by gaining access to economies of scale and scope available to specialist research organisations (Love and Roper, 2002) and the technological risks associated with R&D (Den Hertog and Thurik, 1993). Den Hertog and Thurik (1993) examined the determinants of internal R&D and external R&D, showing that the decision depends on firms' characteristics (size, financial resources, profitability, *etc.*). Building upon Den Hertog and Thurik (1993) findings, we argue that domestic firms can overcome internal R&D budget constraints by using external R&D. Using external R&D is an attractive solution because domestic firms usually cannot afford in-house laboratories (Mowery, 1983). Furthermore, this is also related to financing internal R&D because of risks and uncertain outcomes of such R&D. Hall et al. (2016) highlighted that it is more difficult to finance internal R&D than other investments; they also explained that internal R&D may have negative consequences both for their equity financing – as investors discount the uncertainty on financial and stock markets – and for their debt financing – when collateralisation becomes prohibitive or even impossible.

In contrast, subsidiaries of foreign MNEs have more internal financial resources to finance internal R&D (Nguyen, 2021; Nguyen and Rugman, 2015). They can spread fixed costs of internal R&D over a large sales volume (Den Hertog and Thurik, 1993). Furthermore, research projects on subsidiaries of foreign MNEs require more specific knowledge (Den Hertog and Thurik, 1993).

Going beyond this baseline of arguments, we argue that external R&D may enable domestic firms to improve their product innovation more than subsidiaries of foreign MNEs. It provides opportunities which afford access to new knowledge and technology for innovation. Domestic firms, which are less likely to have global knowledge, may use external R&D to compensate for what they lack in their knowledge base for innovation. They can become creative in how they search for and combine knowledge for innovation because they can use various sources of knowledge (Szulanski, 1996). This is useful for the process of integrating and combining different types of knowledge for innovation (Nonaka and Takeuchi, 1995). In this way, domestic firms may develop ideas for new and/or improved products (Anzola-Román et al., 2018).

In contrast, subsidiaries may already have access to global knowledge to facilitate their international operation within the multinational network. Using external R&D may be less useful for those who already have the knowledge than for those who lack it. Difficulties related to the intellectual property rights appropriability and the lack of suitable expertise of potential external R&D suppliers, compared to a firm's own R&D division, may make external R&D unattractive to subsidiaries of foreign MNEs (Love and Roper, 2002). Thus, subsidiaries of foreign MNEs benefit less from external R&D than domestic firms. Thus, we predict the following:

Hypothesis 4. External R&D has more positive effects on the development of product innovation, in terms of the number of new products, for domestic firms than for subsidiaries of foreign MNEs operating in the same country.

3. Methodology

3.1. Research context, data sources and sample

We focus our research analysis on Spain since it is a relevant country because of its specific economic features. Spain is the world's 14th-largest economy and the fifth-largest in the EU by nominal GDP (The_World_Bank, 2018). Despite this strength in terms of GDP, a report conducted by the OECD (2019) revealed that Spain is below the European average in total R&D over GDP. Furthermore, results from the 2019 Global Innovation Index showed that innovation stands out in Northern Europe, the United States, and China, but not in Spain. Spain is on a clear downward trajectory, holding the 29th position in 2019, which was one lower than the previous year, two lower than in 2015 and three lower than in 2013 (Dutta et al., 2019). Thus, Spain is a relevant country because it requires a new approach to innovation.

To test our hypotheses, we use the Survey on Business Strategies (SBS) for the period from 2006 to 2016. This data source is an annual panel survey operated by the SEPI Foundation, and it is officially supported by the Ministry of Industry to collect firm data from the Spanish manufacturing sector. The SBS is considered a high-quality source of firm information for several reasons: (a) it surveys approximately 1800 firms every year; (b) the questionnaires are rich in detail, including 107 questions focusing on firms' strategies as well as firms' profit and loss statements and balance sheet; (c) sample representativeness is ensured; and (d) the SBS does not suffer from survivor bias because it is an unbalanced panel: when a firm "disappears", this firm is replaced by a statistically similar one. Regarding our panel data, in line with Ramírez et al. (2020), our data includes 11 years of data that widely cover a full economic cycle. Thus, we include both upturn and downturn phases (positive GDP growth rates from 2006 to 2008 followed by the 2008–2014 economic crisis that had severe impacts on Spanish firms, culminating with an economic recovery during the 2014–2016 period).

Our initial sample size was 20,433 firm observations (1857 firms per year on average). To test our hypotheses unambiguously, we paid attention to foreign participation in the company. Following Un (2016: 52), we constrained our sample to companies that were 100 % domestic (*i.e.*, 0 % foreign involvement) and companies that were foreign subsidiaries (*i.e.*, in which the percentage of foreign participation was 100 %). This reduced our sample to 19,634 firm observations (1785 companies per year, on average). This datum is highly relevant since there are only 799 observations (*i.e.*, an average of 76 companies per year) that have mixed-equity ownership. This means that the way of differentiating domestic firms from foreign subsidiaries is accurate since this "all or nothing" nature is highly predominant in the Spanish manufacturing sector and, furthermore, leaves a very small number of companies out of our analyses.

Next, we excluded firms that reported that they engaged in foreign direct investments because we might have relationships that differ for this set of firms, which might distort our results (Salomon and Jin, 2008, 2010; Un, 2016; Un and Rodríguez, 2018). This decreased our sample to 17,191 firm observations. Table 1 shows a breakdown of the sectoral distribution of these manufacturing firms (year: 2016), and we observe that around 90 % were domestic firms and 10 % were foreign subsidiaries. Furthermore, in our sample, there was no presence of foreign MNE subsidiaries in the textile and clothing; leather, fur, and footwear; as well as in the furniture sectors. However, we observe a large presence in the chemical and pharmaceutical sector (32.9 %), vehicles and accessories (29.2 %) and electrical materials and accessories (23.7 %).

For a clear picture of the location of these firms, Fig. 1 shows the geographical locations of manufacturing establishments (in percentages) by the different Spanish Autonomous Communities. Thus, we observe that the highest percentage of domestic manufacturing establishments are concentrated in Catalonia (17.8 %), Valencia (16.4 %), Madrid (12.6 %) and Andalusia (12.4 %); while the highest concentration of foreign MNE establishments is concentrated in Catalonia (27.2 %), Madrid (12.9 %), Basque Country (8.9 %) and Andalusia (8 %). The main divergence is found in the strong presence of domestic firms in the Valencian Community, where only 4.7 % of foreign subsidiaries are located. The reason may lie in their strong tradition of a craft industry, based on local firms (mostly family-owned firms) (Salom and Albertos, 2013).

Finally, we lagged our variables. Thus, our unbalanced panel data included 15,280, 13,594 and 12,273 firm observations (for one-, two- and three-year lags respectively).

Table 1
Industry breakdown of the sample.

	Total number of firms	% domestic firms	% foreign subsidiaries
1. Meat products	64	98.4	1.6
2. Food and tobacco	171	95.9	4.1
3. Beverage	26	96.2	3.8
4. Textiles and clothing	81	100	0.0
5. Leather, fur and footwear	55	100	0.0
6. Timber	43	95.3	4.7
7. Paper	54	90.7	9.3
8. Printing	56	96.4	3.6
9. Chemicals and pharmaceuticals	76	67.1	32.9
10. Plastic and rubber products	73	80.8	19.2
11. Nonmetal mineral products	86	89.5	10.5
12. Basic metal products	36	83.3	16.7
13. Fabricated metal products	177	94.9	5.1
14. Machinery and equipment	69	85.5	14.5
15. Computer products, electronics and optical	21	90.5	9.5
16. Electric materials and accessories	38	76.3	23.7
17. Vehicles and accessories	48	70.8	29.2
18. Other transport equipment	21	90.5	9.5
19. Furniture	54	100	0.0
20. Other manufacturing	31	93.5	6.5
	1280	89.8	10.2

3.2. Variables and measurements

Table 2 summarises the full list of variables and measures used in this research. We acknowledge that the inbound open innovation mechanisms need time to flow back from external entities into the firm's innovative activities. Thus, the benefits we propose may not be achieved until future periods. For this reason, we lag our independent and control variables by one, two and three years (except for those control variables that maintain a homogeneous behaviour over time: Firm_age, Firm_size, Sector_effects, and Year_effects).

First, we analyse the threat of multicollinearity and check the two types that exist: (a) structural multicollinearity; and (b) data multicollinearity. Regarding structural multicollinearity, this appears by default when interactions are introduced into a model (because, *per se*, there is a high correlation between the main effect variables and their interaction) (Frost, 2020; Kutner et al., 2004). To assess whether we should correct it or not, we followed Frost (2020) and mean-centered the continuous variables involved in the interactions and replicated all the analyses. No changes were found that affected the behaviour or significance of the variables. Therefore, we conclude that it is not necessary to perform the mean-center transformation. Regarding data multicollinearity, to evaluate whether there is any data multicollinearity problem among our variables, Table 3 presents the correlation matrix for our variables and their variance inflation factor (VIF) values, and we generate these data for both domestic firms and foreign subsidiaries.

Most correlations are below the recommended threshold of 0.5, so multicollinearity should not be a concern. However, we obtain higher

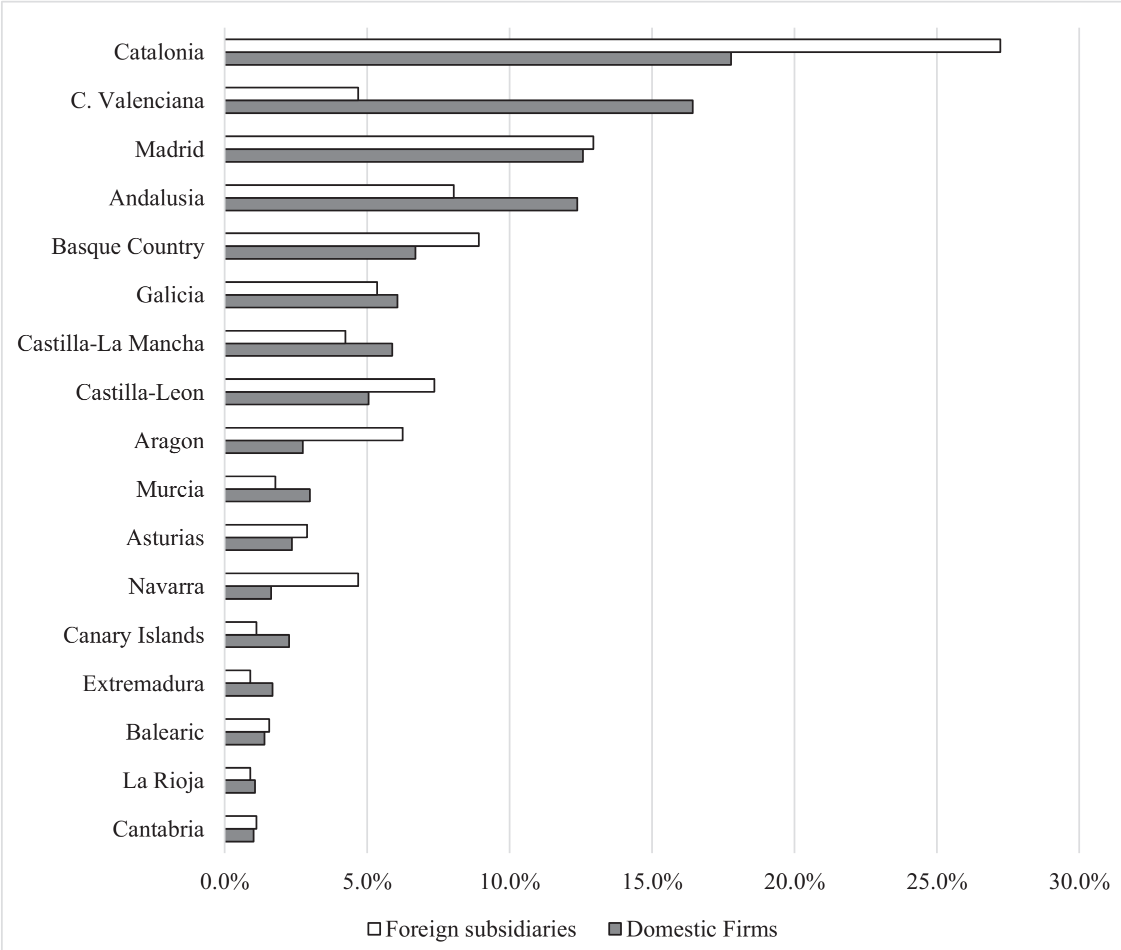

Fig. 1. Distribution of manufacturing establishments (%) by Spanish Autonomous Communities (domestic firms *versus* foreign subsidiaries).

correlations in some specific cases. When examining the correlation of variables for domestic firms, we find five correlations higher than 0.5; and 3 cases in the sample of subsidiaries of foreign firms. These correlations are to be expected, as we observed the correlation of the variable "Sales" with "Firm size" and with "Exports"; as well as the correlation of establishing R&D collaboration agreements with R&D investments. Therefore, we cannot directly rule out an adverse effect of multicollinearity on our results.[1] To further explore the potential threat of these values, we use the statistic VIF. Individual VIF values are all under 5.6 and, therefore, smaller than the recommended threshold of 10, and both average values are under 2.3 and, therefore, smaller than the recommended limit of 6. Hence, our diagnostic tests indicate that there is no threat of multicollinearity (Chatterjee and Price, 1977; Neter et al., 1989).

Second, to provide comprehensible data in calculating means and standard errors, we use the original values of those variables before they are transformed with logarithms. For this reason, we observe high standard errors in some cases. To assess these data properly, we conduct different tests to check the equality of means (we adapt the technique depending on the nature of the variable). Table 3 shows significant differences in all of them.

Third, to conduct a preliminary evaluation of the accuracy of Hypothesis 1, we calculate the mean value of the number of innovative products (0.72 for domestic firms and 3.27 for foreign subsidiaries) and perform different tests (with pooled and panel data) to evaluate if the rates of innovative products of the domestic firms and the foreign subsidiaries are equal. We find significant differences in every single test (all p-values < 0.001). This means that foreign subsidiaries located in Spain produce, on average, approximately 4.5 times more product innovations than Spanish domestic firms. These findings provide preliminary support for Hypothesis 1. Moreover, on average, all our variable values are higher for foreign subsidiaries than for domestic firms, which corroborates the greater endowment of firm-specific advantages of foreign subsidiaries compared to domestic ones.

3.3. Statistical methodology

We use a dependent variable (NIP) that is a non-negative integer-valued count variable, and it is bunched close to or equal to zero. Following the literature, there are two main approaches to address our dependent variable: Poisson or negative binomial regressions. We choose the second technique because we find evidence of overdispersion in our data, and Poisson estimations are sensitive to distributional assumptions (they would generate erroneous results). We evaluate which specification is more appropriate for our model – pooled estimator *versus*

[1] Multicollinearity affects neither the predictive capability of the model, nor the goodness of fit, nor the coefficient estimates of uncorrelated variables (Frost, 2020; Nja, 2013; Paul, 2006).

Table 2
Variables and measures.

	Variable	Abbreviation	Measurement	Previous literature using this measurement
Dependent variable	Number of innovative products	NIP	The number of newly released in the market	Almodóvar et al. (2014); Bianchi et al. (2016); Blundell et al. (1995, 1999); García et al. (2013); Jin et al. (2019); Salomon and Jin (2008, 2010); Salomon and Shaver (2005)
Independent variables	Foreign subsidiaries	Foreign_subsdiary	Dichotomous variable coded with "1" when firms indicate 100 % of foreign participation, and "0" when registering 0 % of foreign participation (*i.e.*, purely domestic firm)	He et al. (2015); Li et al. (2007); Tsang (2005); Un (2016)
	R&D collaboration	R&D_collaboration	Dichotomous variable coded with "1" when firms indicate that they have signed R&D collaboration agreements, and "0" otherwise	Almodóvar and Rugman (2015); Cuervo-Cazurra et al. (2018); Nieto and Santamaría (2007, 2010); Revilla and Fernández (2012); Simeth and Mohammadi (2022); Un et al. (2010)
	Inward (foreign) technology licensing	Foreign_licen	The natural logarithm of inward licensing in euros plus one	Bianchi et al. (2010b); Sikimic et al. (2016); Tsai and Wang (2007)
	External R&D	External_R&D	The natural logarithm of external investments in R&D in euros plus one	Clausen (2009); García-Vega et al. (2019); Lehto and Lehtoranta (2004); Rodríguez and Wiengarten (2017); Tsinopoulos et al. (2019)
Control variables	Highly educated employees	High_education	(Absorptive capacity) The percentage of employees with university degrees over the company's total personnel	Almodóvar et al. (2016); Bianchi and Lejarraga (2016); Olivares-Mesa and Cabrera-Suarez (2006)
	Internal R&D	Internal_R&D	(Absorptive capacity) The natural logarithm of total internal expenditure in R&D activities in euros plus one	Cuervo-Cazurra et al. (2018); García-Vega et al. (2019); Wang and Hagedoorn (2014)
	Exports	Exports	The natural logarithm of the value of exports in euros plus one	Almodóvar et al. (2014); Hu et al. (2016); Salomon and Shaver (2005); Tse et al. (2017)
	Advertisement intensity	Advertisement_int	Advertising expenditures divided by total sales	Jin et al. (2019); Salomon and Shaver (2005)
	Sales	Sales	The natural logarithm of the value of sales in euros plus one	Keum (2021); Kim (2015)
	Firm's age	Firm_age	The number of years in operation since the firm's incorporation	Kafouros et al. (2020); Kotlar et al. (2013); Robeson and O'Connor (2013)
	Firm's size	Firm_size	The natural logarithm of the total number of employees of the company plus one	Cuervo-Cazurra et al. (2018); Kamuriwo et al. (2017)
	Sector fixed effects	Sector_effects	20 manufacturing sectors by CNAE-09	Almodóvar et al. (2021); Shaver (2011)
	Year fixed effects	Year_effects	Bivariate indicators of the year	Tse et al. (2017); Un and Rodríguez (2018); Wang and Hagedoorn (2014)

panel estimator – and the results support the adequacy of using panel data. Therefore, and in line with Cassiman and Golovko (2011), we choose random effects to control for the unobserved firm heterogeneity derived from missing variables. The specification of our nonlinear positive truncated model is as follows:

$$\begin{aligned}\lambda_{it} = exp\Big(&\beta_1 \text{Foreign\_subsdiary}_{i,t-p} + \beta_2 \text{R\&D\_collaboration}_{i,t-p} \\ &+ \beta_3 \text{Foreign\_licen}_{i,t-p} + \beta_4 \text{External\_R\&D}_{i,t-p} \\ &+ \beta_5 \text{Foreign\_subsdiary}_{i,t-p}{}^{*}\text{R\&D\_collaboration}_{i,t-p} \\ &+ \beta_6 \text{Foreign\_subsdiary}_{i,t-p}{}^{*}\text{Foreign\_licen}_{i,t-p} \\ &+ \beta_7 \text{Foreign\_subsdiary}_{i,t-p}{}^{*}\text{External\_R\&D}_{i,t-p} \\ &+ \beta_8 Z_{i,t-p} + \varepsilon_{it}\Big); p = 0, 1, 2, 3\end{aligned}$$

where λ_{it} represents the expected number of product innovations for firm *i* at time *t*, $Z_{i,t\text{-}p}$ denotes a vector of control variables and ε_{it} represents an unobserved error term.

According to Hill et al. (2021), several reasons might cause endogeneity problems: (a) omitted/missing variables; (b) reverse causality; (c) measurement error, where the common method variance is a special case and (d) selection problems when the sample does not accomplish with the feature of randomness.

To avoid the omitted variable bias, we (a) introduced a full set of control variables and (b) performed several sensitivity tests. Regarding control variables, we consider a full and relevant set. Thus, we include nine control variables while micro-organisational studies only introduce 4.48 control variables on average (Atinc et al., 2012: 67). Furthermore, we follow the guidelines provided by Becker (2005) and Atinc et al. (2012), in which we used and cite relevant studies that use these same control variables and measurements in the context of innovation. Regarding our sensitivity test, we evaluate the potential impact of the omitted variable bias by intentionally violating the exogeneity assumption, meaning that we analyse the model with and without control variables and observe how coefficients are affected. Table 4 presents model 1, which only includes control variables; model 2, which only considers our main and interaction effects; and model 3, which shows the full model. Finally, we replicate the analysis for shorter time periods, and the results remain the same. In the next section, we analyse the results, and the coefficient signs and significance all remain mainly the same.

To avoid the reverse causality bias, we took advantage of the longitudinal nature of our study and lagged our independent variables by one, two and three years to force the sense of causality, as well as alleviate concerns about the time it may take for R&D projects to come to fruition and materialise in the marketplace.

Regarding the measurement error, the SBS compiles objective data and completes it with accounting data. Furthermore, we build our variables according to mainstream research. Thus, we rely on the quality of this official source of firm-level data. However, we acknowledge that one special case of the measurement error is the common method variance (Hill et al., 2021). The SBS does not suffer from this bias because this survey has multiple respondents to answer different sections, it guarantees the confidentiality and anonymity of the respondents, it requires factual measures instead of opinions and it is subject to internal control checks (data validation) by the SEPI Foundation (Almodóvar et al., 2021; SEPI_Foundation, 2021).

Selection error occurs when firms are not randomly sampled, but this source of endogeneity is not the case because of the official features of the SBS. As explained above, each year the SEPI Foundation oversees a panel questionnaire of manufacturing firms located in Spain. This governmental institution ensures full representativeness by combining exhaustiveness (for firms with >200 workers) and random sampling criteria (for firms with 10 to 200 employees) where the SBS selects firms according to a proportional, stratified and systematic sampling with a random seed (SEPI_Foundation, 2021).

Table 3
Correlation matrix of independent and control variables (domestic firms and foreign subsidiaries).

		1	2	3	4	5	6	7	8	9	10	Mean	Std. Err.	Mean test	VIF	
1	$R\&D\_collaboration_{t-1}$	1	0.09	0.48	0.14	0.63	0.23	0.00	0.31	0.01	0.34	0.53	0.01	***	1.91	*Foreign MNE subsidiaries*
2	$Foreign\_licen_{t-1}$	0.11	1	0.10	0.20	0.02	0.19	0.10	0.22	0.15	0.21	1501.51	358.88	***	1.14	
3	$External\_R\&D_{t-1}$	0.60	0.10	1	0.13	0.39	0.18	0.11	0.29	0.04	0.35	1.08E+06	3.18E+05	***	1.40	
4	$High\_education_{t-1}$	0.25	0.09	0.21	1	0.18	0.05	0.14	0.10	0.12	-0.02	21.63	0.43	***	1.19	
5	$Internal\_R\&D_{t-1}$	0.70	0.12	0.61	0.28	1	0.24	0.07	0.33	0.03	0.37	7.75E+05	7.05E+04	***	1.84	
6	$Exports_{t-1}$	0.36	0.10	0.33	0.21	0.37	1	0.00	0.52	0.11	0.46	8.43E+07	8.65E+06	***	1.40	
7	$Advertisement\_int_{t-1}$	0.06	0.03	0.04	0.05	0.05	0.05	1	0.13	0.15	0.15	1.10	0.08	*	1.09	
8	$Sales_{t-1}$	0.41	0.17	0.39	0.23	0.43	0.57	0.03	1	0.12	0.85	1.89E+08	1.50E+07	***	4.01	
9	Firm_age	0.14	0.07	0.10	0.10	0.14	0.21	0.06	0.23	1	0.12	34.24	0.55	***	1.06	
10	Firm_size	0.40	0.17	0.39	0.14	0.42	0.51	0.06	0.89	0.20	1	395.49	19.82	***	4.10	
	Mean	0.22	19.69	6.27E+04	11.52	1.19E+05	6.30E+06	0.87	2.19E+07	27.72	91.88				1.91	
	Std. Err.	0.00	4.53	6.97E+03	0.12	1.19E+04	3.62E+05	0.04	7.22E+05	0.15	2.14					
	VIF	2.24	1.04	1.81	1.15	2.33	1.56	1.01	5.52	1.07	5.02	2.28				
		Domestic Firms														

Correlation matrix for foreign subsidiaries is in *blue and italic font*. // Correlation matrix for domestic firms is in black and regular font.
Pearson correlations for two continuous variables and Point-biserial correlations for one dichotomous ($R\&D\_collaboration_{t-1}$) and one continuous variables.
To provide comprehensible data in calculating means and standard errors, we use the original values of those variables before they are transformed with logarithms.
* p-value < 0.05.
*** p-value < 0.001.

4. Results and discussion

4.1. Main models for the analysis of open innovation mechanisms

Table 4 shows the results of the negative binomial models with the NIP as the dependent variable. The Wald chi-square tests show significant values (p-values < 0.001) in every model, so we can affirm that at least one coefficient is statistically different from zero. We explain our results by focusing on model 3.

In testing our hypotheses, and as indicated above, we replicate our models by lagging the variables 1, 2 and 3 years. We first discuss the preliminary results of model 3 with the 1-year lagged variables and then comment on the similarities and differences in the remaining lags. Second, we analyse the interactions graphically for a conclusive test of our hypotheses (showing the 1-year lag in the foreground and the 2 and 3-year lags in the background).

Preliminarily, we observe among the main effects that the Foreign_subsidiary variable is positive and significant ($\beta = 0.460$; p-value $= 0.002$). This seems to support Hypothesis 1 since it reveals that a higher number of product innovations are expected when companies are foreign (*versus* domestic). Likewise, the main-effect variables are all positive. This seems to indicate that R&D collaboration, foreign licensing and external R&D all have positive effects on the number of product innovations. We are aware that Foreign_licen is not significant, but we consider it because its interaction is significant,[2] and it is the p-value of the interaction what determines whether or not it is relevant. Next, we find out that the three interactions are negative and significant. This sign refers to a negative slope correction among firms that are foreign subsidiaries, which suggests that these mechanisms have a more beneficial effect on domestic firms than on foreign subsidiaries. When we analyse the models with lagged variables of 2 and 3 years, a similar, although not exact, behaviour is observed. The main divergence is seen in the R&D_collaboration variable. The main effects are always positive and significant (p-value < 0.001); however, the interaction is only significant in the first lag, but not when lagged 2 or 3 years. This behaviour indicates that entering into technology partnerships with other firms has a positive effect that materialises over the years; however, the expected greater beneficial effect on domestic firms (*versus* foreign subsidiaries) is only observed in the following year; later on, the effect is similar between the two profiles of firms. Regarding the other two explanatory variables, the interactions remain significant over the years and maintain the same signs. Therefore, and apparently, the beneficial effects of these mechanisms are robustly maintained over time.

However, what we explained in the previous paragraph is only an approximation, as we cannot rely solely on the coefficients of the main effects and interactions to understand the true effect of these variables on product innovations because understanding the patterns behind the interactions is not straightforward. Signs of the coefficients are helpful, but negative binomial regressions might return non-intuitive coefficients. Following Bellamy et al. (2014) and Frost (2020), we create a visual display of our findings by graphing the linear predicted innovation output for our three interactions. Therefore, we plot these results to ensure our hypotheses testing.

As recommended by Williams (2012), Fig. 2 plots the predictive margins for the no/yes values of R&D collaboration (lagged one, two and three years) for foreign and domestic firms. These predictive margins are the linear predictions of NIP.

Fig. 2 shows that, in the absence of R&D collaboration agreements, the number of product innovations is higher for foreign subsidiaries than otherwise. This is in line with Hypothesis 1. We observe that R&D collaboration agreements have a positive effect on both domestic and foreign firms in Spain. However, this positive and significant effect is greater for domestic firms. Thus, the predictive margins for the four potential situations (domestic firm/foreign subsidiary and yes/no lagged R&D collaboration agreement) are significant (p-values < 0.001). More specifically, when firms have not entered any research collaboration agreement (R&D_collaboration = 0), foreign subsidiaries show a significantly higher level of innovation than domestic firms do. When firms engage in R&D collaborations with external partners, the impact on product innovations is positive for both domestic and foreign companies; however, there is a significant difference between them. R&D

[2] The fact that the main effect ($Foreign\_licen_{t-1}$) is non-significant and that the interaction including this variable is significant ($Foreign\_licen_{t-1}$*Foreign_subsidiary) means that the total effect of the variable $Foreign\_licen_{t-1}$ on the number of product innovations depends entirely on Foreign_subsidiary.

Table 4
Negative binomial regressions (core models).

	Model 1	Model 2			Model 3		
Main Effects	Foreign_subsdiary	1.000 *** (0.138)	0.952 *** (0.144)	0.939 *** (0.149)	0.460 ** (0.148)	0.372 * (0.154)	0.347 * (0.159)
	R&D_collaboration$_{t-1}$	0.991 *** (0.076)			0.458 *** (0.081)		
	R&D_collaboration$_{t-2}$		0.854 *** (0.082)			0.434 *** (0.087)	
	R&D_collaboration$_{t-3}$			0.687 *** (0.088)			0.356 *** (0.093)
	Foreign_licen$_{t-1}$	0.064 * (0.026)			0.052 (0.027)		
	Foreign_licen$_{t-2}$		0.093 *** (0.026)			0.077 ** (0.028)	
	Foreign_licen$_{t-3}$			0.076 ** (0.028)			0.040 (0.030)
	External_R&D$_{t-1}$	0.061 *** (0.006)			0.034 *** (0.006)		
	External_R&D$_{t-2}$		0.053 *** (0.007)			0.027 *** (0.007)	
	External_R&D$_{t-3}$			0.054 *** (0.007)			0.029 *** (0.008)
Interaction effects	R&D_collaboration$_{t-1}$ & Foreign_subsidiary	−0.643 *** (0.164)			−0.404 * (0.159)		
	R&D_collaboration$_{t-2}$ & Foreign_subsidiary		−0.530 ** (0.170)			−0.293 (0.168)	
	R&D_collaboration$_{t-3}$ & Foreign_subsidiary			−0.460 * (0.179)			−0.228 (0.180)
	Foreign_licen$_{t1}$ & Foreign_subsidiary	−0.108 ** (0.033)			−0.109 ** (0.034)		
	Foreign_licen$_{t-2}$ & Foreign_subsidiary		−0.130 *** (0.034)			−0.129 *** (0.035)	
	Foreign_licen$_{t-3}$ & Foreign_subsidiary			−0.132 *** (0.037)			−0.114 ** (0.038)
	External_R&D$_{t-1}$ & Foreign_subsidiary	−0.037 ** (0.013)			−0.026 * (0.012)		
	External_R&D$_{t-2}$ & Foreign_subsidiary		−0.041 ** (0.013)			−0.028 * (0.013)	
	External_R&D$_{t-3}$ & Foreign_subsidiary			−0.049 ** (0.014)			−0.035 * (0.014)

(*continued on next page*)

Table 4 (*continued*)

		Model 1			Model 2			Model 3		
Control variables	$High\_education_{t-1}$	0.004*						0.004*		
		(0.002)						(0.002)		
	$High\_education_{t-2}$		0.003						0.003	
			(0.002)						(0.002)	
	$High\_education_{t-3}$			0.003						0.004
				(0.002)						(0.002)
	$Internal\_R\&D_{t-1}$	0.096***						0.068***		
		(0.006)						(0.007)		
	$Internal\_R\&D_{t-2}$		0.075***						0.050***	
			(0.006)						(0.007)	
	$Internal\_R\&D_{t-3}$			0.054***						0.033***
				(0.006)						(0.007)
	$Exports_{t-1}$	0.034***						0.030***		
		(0.006)						(0.006)		
	$Exports_{t-2}$		0.041***						0.038***	
			(0.007)						(0.007)	
	$Exports_{t-3}$			0.039***						0.037***
				(0.007)						(0.007)
	$Advertisement\_int_{t-1}$	0.013						0.010		
		(0.010)						(0.010)		
	$Advertisement\_int_{t-2}$		0.007						0.006	
			(0.009)						(0.008)	
	$Advertisement\_int_{t-3}$			0.004						0.004
				(0.007)						(0.006)
	$Sales_{t-1}$	−0.031						−0.053		
		(0.046)						(0.046)		
	$Sales_{t-2}$		−0.022						−0.043	
			(0.048)						(0.048)	
	$Sales_{t-3}$			−0.015						−0.027
				(0.051)						(0.052)
	Firm_age	0.005**	0.006**	0.006**				0.005**	0.005**	0.005*
		(0.002)	(0.002)	(0.002)				(0.002)	(0.002)	(0.002)
	Firm_size	0.141*	0.185**	0.230***				0.147**	0.193**	0.234***
		(0.057)	(0.058)	(0.061)				(0.057)	(0.058)	(0.062)
	Sector_effects	*Yes*	*Yes*	*Yes*				*Yes*	*Yes*	*Yes*
	Year_effects	*Yes*	*Yes*	*Yes*				*Yes*	*Yes*	*Yes*
	_cons	−2.017**	−2.136***	−2.229**	−1.892***	−1.693***	−1.510***	−1.715**	−1.797**	−2.024**
		(0.583)	(0.612)	(0.658)	(0.066)	(0.070)	(0.075)	(0.591)	(0.630)	(0.686)
	Wald test	926.0***	711.69***	543.0***	530.27***	355.28***	241.89***	1033.51***	788.84***	608.18***
	N° obs.	15,280	13,594	12,273	15,280	13,594	12,273	15,280	13,594	12,273

Standard error appears in parentheses ().

* p-value < 0.05.

** p-value < 0.01.

*** p-value < 0.001.

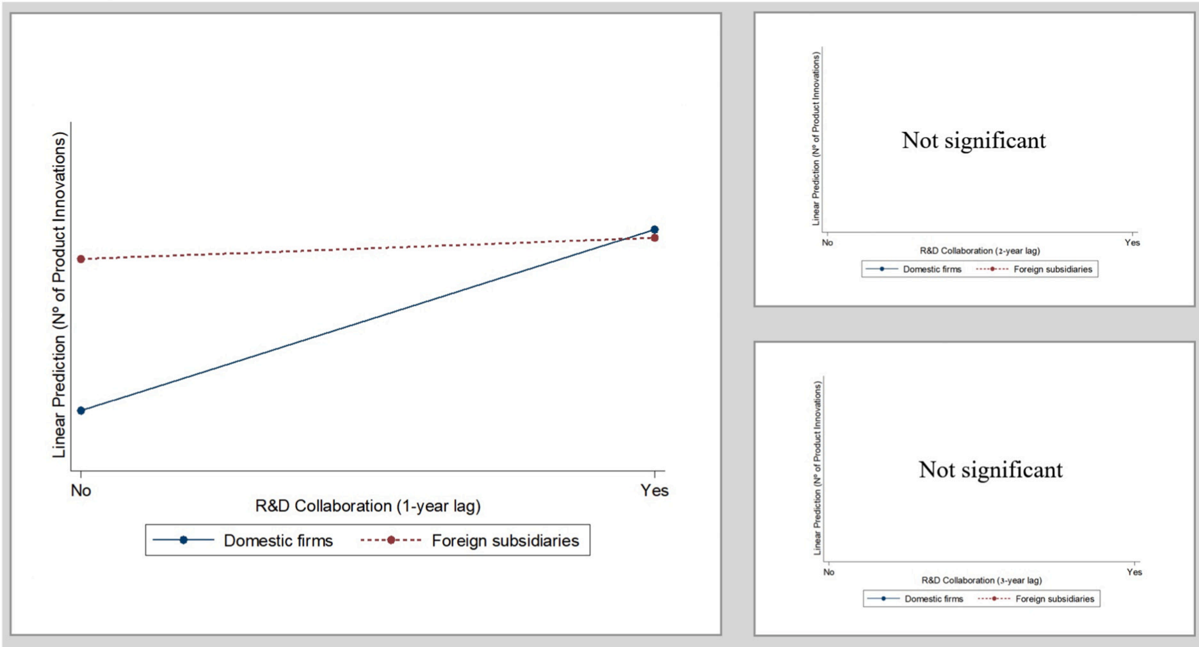

Fig. 2. Linear predicted innovativeness between domestic and foreign companies for R&D collaboration.

collaborations have a more positive effect on domestic firms. As a result, when both types of firms engage in R&D collaboration agreements, domestic firms show a superior level of innovativeness compared to foreign subsidiaries. Therefore, R&D collaborations are a suitable mechanism for domestic firms to outperform foreign firms in terms of innovation. This result supports Hypothesis 2. However, this mechanism only shows this innovation-enhancing effect for domestic (*vs.* foreign) firms after the first year, in the following years, the positive effect occurs to the same extent for both profiles of firms, so that the interactions lose their significance. In this respect, we understand that the R&D_collaboration variable is a binary/dummy variable that only captures whether firms have or do not have collaborations, but a part of the richness of this open innovation mechanism is lost in the measurement. For this reason, and in an attempt to provide the highest possible level of analysis of a firm's open innovation efforts, in the following subsection we will examine this variable in greater depth.

Fig. 3 shows that, in the absence of foreign technology licensing, the number of product innovations is higher for foreign subsidiaries than for domestic firms. This is also in line with Hypothesis 1. We also observe that the impact of buying foreign technology licenses (one-year lag) is significantly different for domestic firms and foreign subsidiaries. The predictive margins for the four potential situations are significant (p-values < 0.001). Thus, as domestic firms invest in licensing, their predicted number of product innovations sharply increases. This result

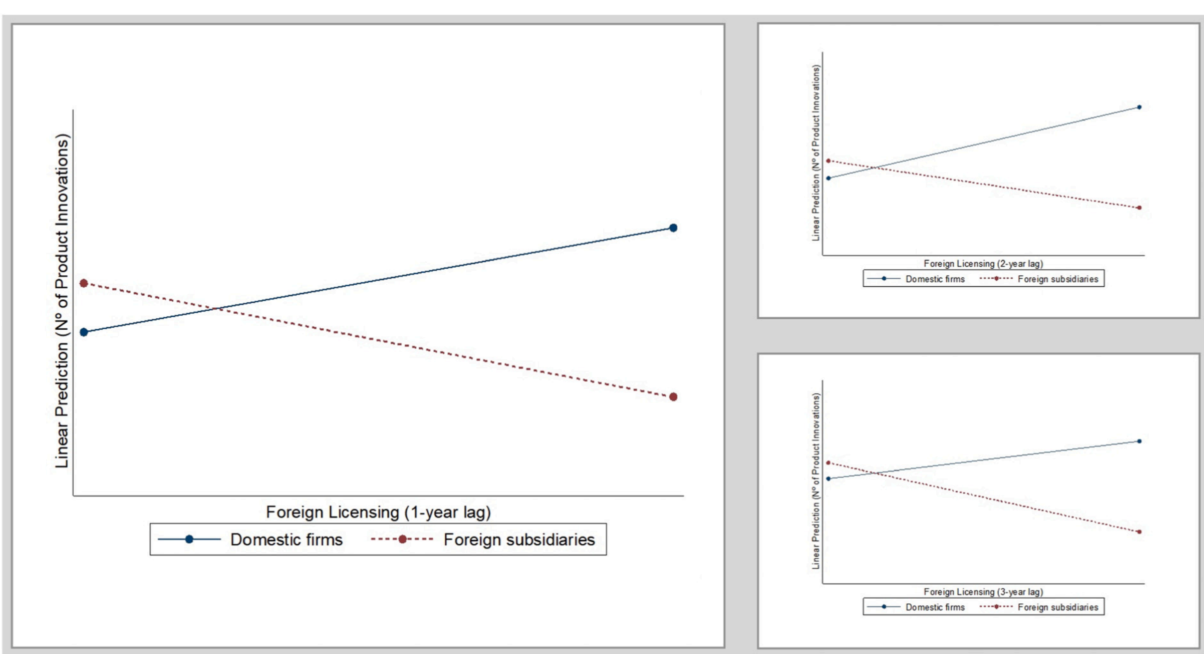

Fig. 3. Linear predicted innovativeness between domestic and foreign companies for inward technology licensing.

supports Hypothesis 3 because foreign inward licensing is an effective mechanism for domestic firms to outperform foreign subsidiaries in terms of innovation.

Although this result substantially supports Hypothesis 3, we further examine the unexpected behaviour of this mechanism on the level of product innovations of foreign subsidiaries. We would expect a positive impact in both cases; however, investment in foreign licensing damages the innovation performance of foreign subsidiaries. Thus, as the investment in inward licensing increases, the number of product innovations by foreign subsidiaries decreases. Several studies discuss the adverse effects the acquisition of technology licenses may have on innovation. For example, Mytelka (1978) explained a "technology dependence syndrome" where a firm that embraces licensing becomes technologically self-reliant, meaning that licensing generates a psychological environment of dependency where a firm's management judges that the firms cannot develop their own technology for new products and, consequently, become less innovative. Basant (1992) argued that foreign technology licensing harms the firm's innovativeness because there is a substitutive effect against the firm's own technology development. More recently, Lee et al. (2017) and Yu et al. (2019) showed how in-licensing is not always advantageous for innovative performance and, under certain circumstances, they found a negative effect. Since we only find this adverse impact among foreign subsidiaries, the interpretation of this result is somewhat difficult, so in-depth empirical research is needed to disentangle the complex nature of in-licensing. Moreover, this behaviour is robustly maintained over the years. Thus, in the three graphs presented in Fig. 3, the slopes and magnitudes are almost identical.

Finally, Fig. 4 represents predictive margins for the minimum and maximum values of the impact of external R&D on the linear prediction of NIP, and this relationship is shown for foreign subsidiaries *versus* domestic firms. The predictive margins for the four potential situations are significant (p-values < 0.001). We observe that, when firms do not spend any funds on external R&D, the level of product innovation is significantly higher among foreign subsidiaries than otherwise. Thus, all our analyses fully support Hypothesis 1. Furthermore, external R&D has a significant and positive impact on both firm types. However, the slope is significantly steeper for domestic firms, which implies that the impact of external R&D is greater for domestic firms than otherwise. This result supports Hypothesis 4 because domestic firms outperform foreign subsidiaries by investing in external R&D.

In addition, when we analyse their evolution after 2 and 3 years, we see that the markedly positive effect on purely domestic firms remains almost identical. However, the effect on foreign subsidiaries evolves negatively. Thus, after two years, the slope flattens considerably. And after three years, the slope becomes negative. Thus, this mechanism is useful for domestic firms to overcome the liability of localness.

The control variables all behave as expected, except for advertisement intensity and sales. In this aspect, we note that these variables do not have a direct effect on new product development; so, we cannot consider any of these variables as determining elements of innovation. Of great theoretical and empirical relevance are the control variables Internal_R&D and High_education. These variables have been widely contrasted in the literature as measures that favour a firm's absorptive capacity (Bianchi et al., 2010b; Cohen and Levinthal, 1990; Gao et al., 2008; Kafouros et al., 2020; Zahra and George, 2002). Thus, firms require minimum knowledge endowments that enable them to be capable of identifying, understanding, assimilating, and transforming new knowledge into innovations. For this reason, in-house R&D expenditures within the firm and the qualification level of the employees are relevant proxies for our study. Regarding Internal_R&D, it is significant (all p-values < 0.001) and positively affects the number of product innovations (Atuahene-Gima, 1992; Cohen and Levinthal, 1990). Regarding High_education, we find a positive and significant effect on innovation, but only after the first year. This behaviour could be understood in relation to the obsolescence of knowledge in dynamic environments. Thus, this seems to point to the fact that, in order to enhance the positive effect of staff skills on new product development, staff should be regularly trained. In line with the literature on "learning by exporting" (Salomon and Shaver, 2005), exports positively impact a firm's number of product innovations (Almodóvar et al., 2014; Hu et al., 2016; Tse et al., 2017). Regarding Firm_age, which reflects a firm's experience, is a firm-specific advantage that positively impacts a firm's innovativeness. We also consider Firm_size because it is relevant in determining the firm's innovative performance, larger firms have superior firm-specific advantages to develop new products successfully. We account for sector and year fixed effects to capture systematic differences among sectors and years, they are significant. Apart from

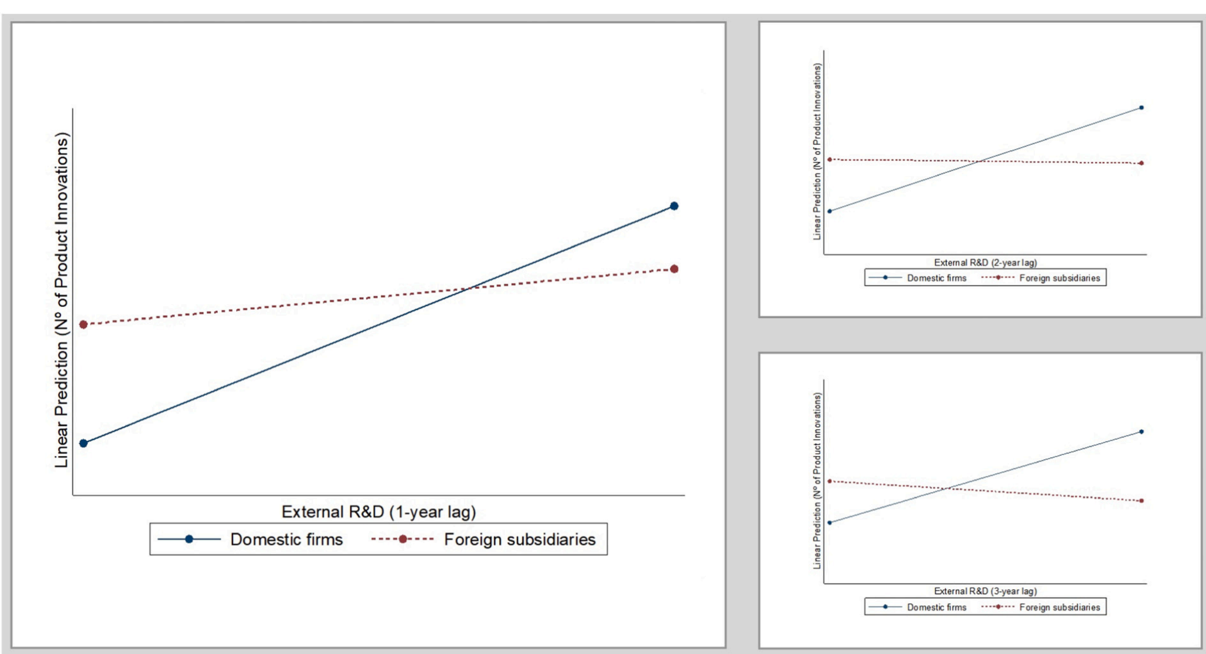

Fig. 4. Linear predicted innovativeness between domestic and foreign companies for external R&D.

High_education, all of them show a robust behaviour over the years.

4.2. Supplementary models for analysing the mechanism of R&D collaboration agreements

As mentioned above, the main weakness of our main model is the measurement of R&D collaboration agreements through a dummy variable. Although this dichotomous measurement has been used extensively in the literature (Almodóvar and Rugman, 2015; Cuervo-Cazurra et al., 2018; Nieto and Santamaria, 2007, 2010; Revilla and Fernández, 2012; Un et al., 2010), our data do not allow us to understand the qualitative reality behind it. However, we do believe it is useful to provide a greater level of detail to understand the complexity of this mechanism. Moreover, this supplementary approach also offers the possibility to corroborate the robustness of our results.

Thus, the SBS allows us to know the profile of firms with which R&D collaboration agreements are signed (all dummy variables). Thus, we replicate all our models below, but replace the R&D_collaboration variable with its disaggregation by partner profile: (a) competitor; (b) customer; (c) supplier; and (d) research institutes or universities.

When analysing Table 5, we can observe the great similarity of the results with Table 4 (both in the signs of the coefficients and in the magnitudes). Therefore, we will only focus on discussing the results of the disaggregation of the R&D_collaboration variable.

Firstly, the lack of significance of R&D collaboration agreements with competitors is noteworthy. This type of agreement does not seem to have any effect on the improvement of firms' innovative capabilities (neither in domestic nor in foreign firms). This result is aligned with previous studies which explain that collaborations with competitors on product innovations are the least profitable (Nieto and Santamaria, 2007). This is probably because much of the competitive advantage may be linked to the firm's capability to develop new products, and collaborating with a competitor may hinder this.

Secondly, we observe that partnerships with customers are fruitful after the first year, but their effect is lost after two to three years of time. Moreover, Table 5 shows the non-significance of interactions, implying that customers agreements are just as beneficial for domestic firms as for foreign firms. Thus, this type of collaboration, while beneficial for domestic firms, does not demarcate them from foreign subsidiaries.

Thirdly, and similar to the previous case, collaboration agreements with suppliers have a positive and significant effect on innovation outputs, but only in the main effects, not in the interactions. This means that establishing this type of agreement is beneficial for improving firms' innovative capabilities and enhancing the development of new products. However, the beneficial effect is similar for domestic firms as for foreign subsidiaries. This positive effect is maintained after one, two and three years in a stable manner. Therefore, it cannot be considered a differentiating mechanism that particularly boosts domestic Spanish firms.

Fourth and finally, we find the type of collaboration that is behind the effective and differentiating mechanism shown in Table 4. Thus, of the different partners with which a collaboration agreement can be established, the only one that has a positive effect but, after one first year, has a most beneficial effect for domestic firms (and not for foreign subsidiaries) are agreements with universities and research institutions. Thus, in order to correctly analyse the effect that this mechanism has on innovation outputs, we present Fig. 5.

Fig. 5 allows us to corroborate our hypotheses 1 and 2. With respect to Hypothesis 1, the figure shows how in a scenario with zero collaboration agreements with universities or research institutions, the level of product innovations is higher for foreign subsidiaries than for purely domestic firms. However, regarding Hypothesis 2, we observe that when this type of research agreement is established, domestic firms outperform foreign subsidiaries in product innovations after one year.

In conclusion, we can observe how our results, although novel due to their approach to domestic firms, align with the existing literature. Thus, our results would be consistent with the approach of Un et al. (2010) who explained how different types of R&D agreements differ from each other in terms of the ease of access to the knowledge they generate. Thus, they propose that the type of partners that will most enhance product innovations are universities and research institutions, closely followed by R&D collaborations with suppliers; then, with customers and, in the last place, with competitors. Our results are also in line with the qualitative approach of Buganza and Verganti (2009) who presented four case studies that supported the high relevance of R&D collaboration agreements with universities as one of the most relevant sources of inbound knowledge within the open innovation realm.

5. Discussion and conclusions

5.1. Implications for theory

Our study makes three new contributions to the literature. We not only find evidence of the large differences in product innovation between domestic firms *versus* subsidiaries of foreign MNEs, but also identify different mechanisms that domestic firms can use to boost their innovative capacity.

First, we build upon the knowledge-based view of firms and the open innovation literature to theorise that product innovation reflects a firm's capability to utilise different external knowledge sources in an integrative manner besides the existing internal knowledge derived from internal R&D. Our key theoretical contribution is to conceptualise and provide new empirical evidence on how the access to a global, external, and diverse knowledge base, and the utilisation of external knowledge, affects product innovation differently between domestic firms and foreign subsidiaries. Specifically, our study sheds new light on the role of each of the external knowledge sources of three mechanisms of open innovation of R&D collaboration, inward technology licensing and external R&D for innovation in its entirety – and how these mechanisms enable domestic firms to improve their product innovation. Although prior research has examined different aspects of product innovation, the knowledge-based view and the open innovation approach have not been applied to product innovation for two different types of firms at the level of detail as we do. Previous studies examine each of these external knowledge sources individually and thus have provided fragmented insights. We provide a solid theoretical perspective underpinning this phenomenon.

Second, we extend the literature on inbound open innovation by analysing how different knowledge inflows from external sources impact domestic firms *versus* foreign subsidiaries. This research is among the first to identify a set of mechanisms which can help domestic firms enhance their product innovations. Our study analyses three mechanisms of open innovation: R&D collaborations, inward technology licensing and external R&D. Our findings confirm that in the absence of these mechanisms, foreign subsidiaries develop and launch more product innovations than domestic firms; however, when domestic firms invest in these mechanisms, they outperform subsidiaries of foreign MNEs (even if these subsidiaries also invest in these knowledge sources). In examining the impacts of these three mechanisms on product innovation, we highlight the roles that these mechanisms play in product innovation. We also find that domestic firms with a strong ability to utilise these three mechanisms will innovate more than subsidiaries of foreign MNEs. In this way, our study differs from most prior research which investigates one of the three mechanisms separately and ignores the entirety and the integrative approach that domestic firms may use to innovate their products.

Third, we advance the knowledge of product innovation by differentiating the behaviour of domestic firms *versus* subsidiaries of foreign MNEs. We compare product innovation of domestic firms and foreign subsidiaries. Our findings show significant differences in product innovation between these two types of firms. We find that subsidiaries of foreign MNEs introduce more product innovations to the market than domestic firms. The findings suggest that subsidiaries of foreign MNEs

Table 5
Negative binomial regressions (supplementary model).

		Model 3 (extra)					
Main effects	Foreign_subsidiary	0.331 (0.139)	*	0.304 (0.147)	*	0.331 (0.152)	*
	R&D_collaboration$_{t-1}$ (with Competitors)	0.002 (0.149)					
	R&D_collaboration$_{t-2}$ (with Competitors)			−0.099 (0.167)			
	R&D_collaboration$_{t-3}$ (with Competitors)					−0.100 (0.182)	
	R&D_collaboration$_{t-1}$ (with Customers)	0.179 (0.083)	*				
	R&D_collaboration$_{t-2}$ (with Customers)			0.066 (0.089)			
	R&D_collaboration$_{t-3}$ (with Customers)					−0.006 (0.097)	
	R&D_collaboration$_{t-1}$ (with Suppliers)	0.267 (0.080)	**				
	R&D_collaboration$_{t-2}$ (with Suppliers)			0.305 (0.087)	***		
	R&D_collaboration$_{t-3}$ (with Suppliers)					0.216 (0.095)	*
	R&D_collaboration$_{t-1}$ (with Uni. and research inst.)	0.139 (0.074)					
	R&D_collaboration$_{t-2}$ (with Uni. and research inst.)			0.203 (0.079)	*		
	R&D_collaboration$_{t-3}$ (with Uni. and research inst.)					0.269 (0.084)	**
	Foreign_licen$_{t-1}$	0.057 (0.027)	*				
	Foreign_licen$_{t-2}$			0.079 (0.028)	**		
	Foreign_licen$_{t-3}$					0.041 (0.031)	
	External_R&D$_{t-1}$	0.035 (0.007)	***				
	External_R&D$_{t-2}$			0.027 (0.007)	***		
	External_R&D$_{t-3}$					0.028 (0.008)	***
Interaction Effects	R&D_collab. with Comp.$_{t-1}$ & Foreign_subsidiary	0.426 (0.280)					
	R&D_collab. with Comp.$_{t-2}$ & Foreign_subsidiary			−0.043 (0.306)			
	R&D_collab. with Comp.$_{t-3}$ & Foreign_subsidiary					0.276 (0.308)	
	R&D_collab. with Customers$_{t-1}$ & Foreign_subsidiary	0.086 (0.169)					
	R&D_collab. with Customers$_{t-2}$ & Foreign_subsidiary			0.291 (0.179)			
	R&D_collab. with Customers$_{t-3}$ & Foreign_subsidiary					0.117 (0.193)	

(*continued on next page*)

Table 5 (*continued*)

		Model 3 (extra)					
	R&D_collab. with Supp.$_{t-1}$ & Foreign_subsidiary	−0.033					
		(0.167)					
	R&D_collab. with Supp.$_{t-2}$ & Foreign_subsidiary			−0.221			
				(0.173)			
	R&D_collab. with Supp.$_{t-3}$ & Foreign_subsidiary					−0.156	
						(0.186)	
	R&D_collab. with Univ.$_{t-1}$ & Foreign_subsidiary	−0.336	*				
		(0.149)					
	R&D_collab. with Uni.$_{t-2}$ & Foreign_subsidiary			−0.265			
				(0.161)			
	R&D_collab. with Uni.$_{t-3}$ & Foreign_subsidiary					−0.310	
						(0.176)	
	Foreign_licen$_{t-1}$ & Foreign_subsidiary	−0.128	***				
		(0.035)					
	Foreign_licen$_{t-2}$ & Foreign_subsidiary			−0.134	***		
				(0.035)			
	Foreign_licen$_{t-3}$ & Foreign_subsidiary					−0.113	**
						(0.038)	
	External_R&D$_{t-1}$ & Foreign_subsidiary	−0.032	*				
		(0.013)					
	External_R&D$_{t-2}$ & Foreign_subsidiary			−0.031	*		
				(0.013)			
	External_R&D$_{t-3}$ & Foreign_subsidiary					−0.035	*
						(0.015)	
Control variables		*Yes*		*Yes*		*Yes*	
	_cons	−1.919	**	−1.829	**	−2.014	**
		(0.595)		(0.632)		(0.687)	
	Wald test	1053.61	***	801.01	***	613.49	***
	N° obs.	15,280		13,594		12,273	

Due to the large size of this table, we do not present the results of the control variables. They all behave in the same way as in Table 4.
Standard error appears in parentheses ().
* p-value < 0.05.
** p-value < 0.01.
*** p-value < 0.001.

have overcome the liability of foreignness and have a better competitive position in markets. They leverage their unique position of dual embeddedness into the internal MNE network and external networks with local partners to source and acquire knowledge created by parent firms in home countries, as well as access resources and knowledge in host countries and generate a new knowledge bundle (Bartlett and Ghoshal, 1989). In this way, they develop competitive advantages and contribute to the knowledge and innovation of the parent firms (Rugman and Verbeke, 2001). In contrast, domestic firms' innovative performance is significantly lower than that of foreign subsidiaries.

We note although there is a rich literature on innovation from the perspective of subsidiaries of foreign MNEs, research on product innovation from the perspective of domestic firms has been largely underexplored. Our study is among the first few attempts to uncover the differences in product innovation between these two groups of firms when we examine the phenomenon from the perspective of domestic firms. Additionally, we focus on identifying three mechanisms for domestic firms to improve their product innovation.

5.2. Implications for managers

Our findings provide relevant insights for managers of domestic firms as they suffer fierce competition from foreign entrants. This study shows that managers of domestic firms can use different open innovation mechanisms to improve their competitive position and outperform foreign subsidiaries.

First, managers of domestic firms can use R&D collaboration agreements to improve their ability to develop and introduce innovative products to the market. This external inflow of knowledge has been found to be an effective mechanism for outperforming foreign competitors since it has a greater impact on domestic firms' innovative performance than on their foreign counterparts. Our finding on the types of partners that domestic firms can conduct R&D collaboration by the order of (i) universities and research institutions; (ii) suppliers; (iii) customers; (iv) competitors provides a clear and straightforward implication for managers.

Second, managers of domestic firms can invest in foreign technology licensing in order to acquire or improve their firms' knowledge base and innovate. Developing new products from scratch is a time-consuming and expensive process. Additionally, firms need a solid background to

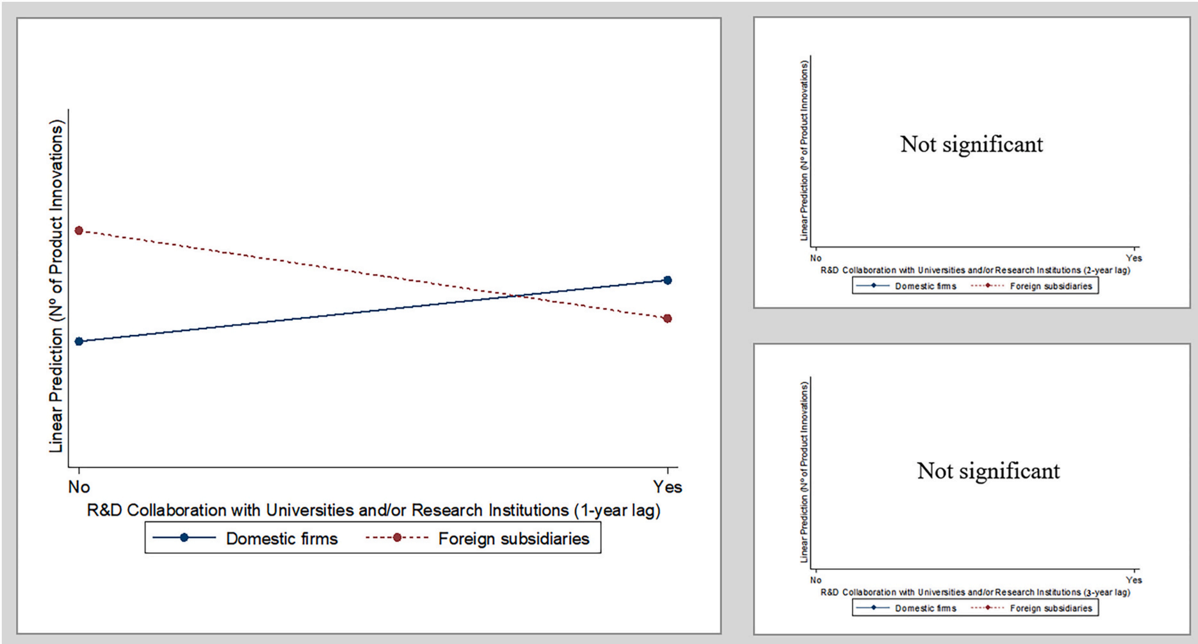

Fig. 5. Linear predicted innovativeness between domestic and foreign firms for R&D collaboration with universities and/or research institutions.

develop elements which are involved in a new prototype. Through in-licensing, managers of domestic firms can reduce costs and utilise this knowledge to accelerate the development of new products. Thus, our study shows that this mechanism is effective in enhancing the domestic firms' innovative output.

Third, our research finds that domestic firms invest much less in internal R&D than foreign subsidiaries. Our results show that managers of domestic firms can overcome the budget constraints on in-house laboratories by investing in external R&D. This is an effective mechanism to overtake foreign subsidiaries in terms of product innovations. Even when foreign competitors also invest in external R&D, the effect is greater for domestic firms than for foreign subsidiaries.

5.3. Limitations and future research directions

Our study suffers from two main limitations. First, the SBS ensures the sample representativeness; however, our results may only reflect the Spanish manufacturing sector. Therefore, further research on the service sector or other countries is highly recommended. Second, quantitative analysis and measurements are supported by several prior studies. However, qualitative research techniques and alternative measurements might offer a deeper understanding of the open innovation phenomenon.

We empirically examine the types of partners in R&D collaboration (customers, suppliers, universities, research institutes and competitors). One potential direction for future research is to explore the forms of R&D collaboration and the performance outcome.

Our results show an unexpected behaviour in inward licensing. Its positive effect and its effectiveness as a mechanism to improve product innovation are validated. However, its adverse impact on foreign subsidiaries is unforeseen. Therefore, another potentially fruitful topic for further research is analysing what causes the negative influence of in-licensing on product innovation.

Another avenue for future research is to explore further in detail the impacts of external R&D on product innovation. Further research on the benefits and costs of external R&D *versus* internal R&D will offer relevant insights.

We also acknowledge that this research only focuses on inbound open innovation mechanisms. Further research is needed to explore other potential mechanisms, such as imitation *versus* innovation, backward engineering, and migration of employees from subsidiaries of foreign MNEs that domestic firms may use to overcome disadvantages in product innovation.

Data availability

The authors do not have permission to share data.

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