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Dynamic effects of learning on the innovative outputs and productivity in Spanish multinational enterprises

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Abstract Empirical studies have consistently illustrated the existence of a relationship between the level of productivity and the international commitment of firms. Few studies have considered the effects of learning by foreign direct investment (FDI). We use a sample of Spanish manufacturing firms to analyze the effect that the multinational enterprise status of a firm has on its ex-post innovative performance and productivity. Our findings reveal dynamic positive effects of FDI on the technological performance of firms, with increments in patents and product innovation taking place before subsequent increments in productivity occur.

Keywords Learning by FDI · Firm heterogeneity · Knowledge flows · Productivity · Innovative performance

JEL Classification O33 · F23 · O31 · L25

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1 Introduction

1.1 Motivation

Learning abroad is a fundamental argument employed in the international business (IB) and economics literatures to explain why firms from countries outside the group of the richest economies and without solid technological capabilities use foreign direct investment (FDI) in their internationalization process and become multinational enterprises (Mathews 2002, 2006; Luo and Tung 2007; Guillén and García-Canal 2010). The support for this observation relies on the prevalence of a different set of firms' strategies focusing on knowledge seeking. The relevant idea is that firms from these countries can build new capabilities abroad following a particular learning process. This existence of this relationship is illustrated in the current paper through an analysis of the effects of FDI on the innovation and productivity of Spanish manufacturing multinational enterprise (MNE) firms.

As a matter of context, Spain is an intermediate country in technological terms (Molero et al. 1995), whose salient feature is that outward FDI flows have been growing considerably since the nineties together with the emergence of a large fleet of multinational companies. The number of Spanish MNE has increased by 37% on average during the period 2000–2009, a figure that reveals the importance acquired by domestic MNE in the Spanish economy. This percentage has been retrieved from the ESEE database (Encuesta de Estrategias Empresariales), which provides the results from a survey conducted annually by the Spanish Science and Technology Ministry among manufacturing firms with more than 10 employees. The sample represents around 22% of all manufacturing employment, covering the total number of firms with more than 200 employees and a representative number of firms with 10–200 employees.

These MNE come from a country without a solid technological base, but have been successful abroad even at a faster rate than those from other, more developed, countries. To explain this fact, it has been recognized that Spanish firms have shown special learning abilities and, therefore, the acquisition of foreign knowledge has gained considerable importance in their internationalization process (Guillén and García-Canal 2010).

There are two main dimensions regarding the learning possibilities derived from foreign knowledge. On the one hand, learning effects can be generated through spillover effects, which allow domestic firms to acquire knowledge from foreign firms located in the country (Alvarez and Molero 2005). On the other hand, firms can learn when they become internationalized. That is, being a MNE allows them to acquire and assimilate international knowledge by learning abroad, leading to expected impacts on both their innovative output and productivity (Guillén and García-Canal 2010). This dimension is especially relevant when the knowledge base is weak in which case learning effects will be higher (Kafouros et al. 2012). Therefore, these learning effects may be crucial for upgrading in less developed countries (Yang et al. 2008), or in those economies characterized by technological lagging industries. This learning process can be particularly relevant in catching-up European economies such as Spain (Salomon and Jin 2007).

The current paper is devoted to analyze the effects of learning abroad by FDI on the innovative outputs and productivity level of Spanish manufacturing firms. In other words, its main objective is to verify whether the MNE status of firms has ex-post effects on patents, product innovation and productivity. This implies studying the relationship between innovation and MNEs in a different direction than is usually done. That is, the causality relationship studied in this paper goes from MNEs to innovation.

There are two main theoretical streams that support this type of empirical analysis. The first one consists of the models and evidence on firms' heterogeneity that connect productivity with the level of international commitment (Melitz 2003; Helpman et al. 2004; Wagner 2007). The main idea emphasized by these models is that exporter firms show higher levels of productivity as a result of learning by exporting effects. However, this literature has devoted scarce or null attention to learning effects by FDI. Other theoretical roots regarding the possibilities offered by learning abroad follow from the concept of international knowledge as a main source of competitive advantage for firms. The idea is that firms are in contact with new knowledge in host locations and this would allow for learning through its incorporation in their production functions, increasing their innovative outputs and productivity (Mudambi 2002; Mudambi and Navarra 2004; Castellani and Zanfei 2007; Belderbos et al. 2013; Kafouros et al. 2012; Mudambi et al. 2013).

The combination of firms' heterogeneity and knowledge flows in the MNE literature provides us with the adequate theoretical body to define our main research questions. The first one consists of analyzing to what extent firms learn abroad using investment as an international expansion strategy. The second question is determining whether this learning process may be reflected in an ex-post increase of innovative output and productivity levels. Time constitutes a crucial dimension in our proposal, which is the reason why a lag structure becomes a key aspect of our empirical design.

The empirical analysis examines a panel of Spanish firms that have at least one establishment in a foreign location during a period of 10 years comprised between 2000 and 2009. Given the argument that learning abroad effects do not immediately materialize in a productivity increase but can be more easily observed through innovative outputs, we will focus on two selected indicators of innovative outputs -product innovation and patent applications (both in Spain and in foreign locations), while using value added over sales as an indicator of productivity (Mudambi and Navarra 2004; Salomon and Shaver 2005 Castellani and Zanfei 2007; Salomon and Jin 2007; Silva et al. 2012). Finally, the existence and extent of learning effects will be controlled by several variables related to the absorptive capacity of firms together with the specific structural characteristics of these latter ones such as size and industry. These specific features have been incorporated, among others, by Yamin and Otto (2004) and Petersen et al. (2008) in similar analytical settings.

1.2 Contribution

Our empirical findings reveal that the MNE status plays an important role in the generation of ex-post innovative outputs for Spanish manufacturing firms. This means that learning through FDI in internationalized firms is shown in an ex-post increase of both product innovation and patent applications. However, these effects differ when considering each indicator individually. In the case of patent applications, the effects derived from the MNE status become evident in the year right after the internationalization process takes place (t + 1), as well as in the subsequent year (t + 2). However, when innovation products are taken as an indicator of innovative output, the ex-post effects of internationalization do not appear immediately but a longer period is required to observe positive results. We have to wait until the second year after internationalization (t + 2) for the effects derived from the MNE status of the firm to show through innovative outputs.

We apply two robustness tests to account explicitly for the technological sector within which the MNE operates and the relative level of development of the countries hosting the FDI. The first test illustrates how the internationalization effect on patents and product innovation concentrates on high and medium tech industries, respectively. When considering the level of development of the host countries, our results show that their influence on the learning process of the MNE is stronger among high and medium income hosts, while low-income ones exert almost no influence.

At the same time, even when learning abroad is confirmed through its effect on innovative outputs, we have to wait 2 years after the internationalization process takes place to observe the resulting effects on productivity. This finding allows us to confirm that firms with a MNE status learn abroad by FDI and that the acquired international knowledge increases both their innovative outputs and, after a given time lapse, their productivity levels. The learning waves resulting from the assimilation of the knowledge acquired through the internationalization process of firms are described in Fig. 1.

This figure is based on the curvilinear relationship between multinationality and performance described, among others, by Kotabe et al. (2002) and Gomes and Ramaswamy (1999). The main difference with respect to ours is the introduction of the innovative output and productivity variables in the relationship.

Figure 1 illustrates the dynamic sequential nature of the learning process triggered by the internationalization strategy of firms, with product innovations taking place before the corresponding process improvements are implemented. Note how initial innovative output waves are followed by productivity increments, though both processes are generated by the

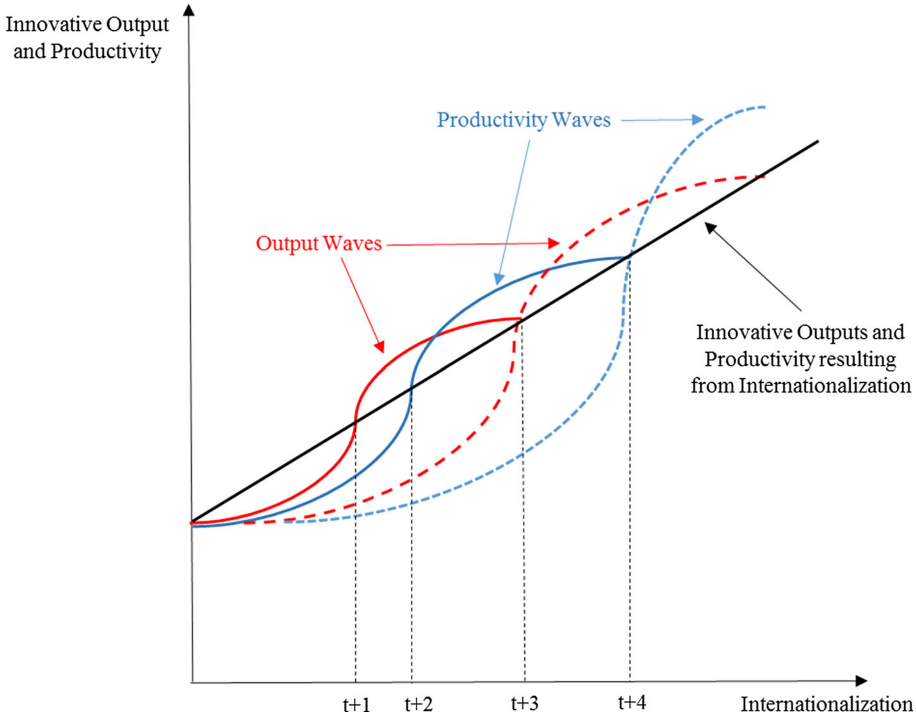

Fig. 1 Sequential output and productivity waves derived from learning by FDI

same internationalization strategy of firms. Note also that the relative width of each wave could be modified and two innovative output waves be allowed to take place per each productivity wave.

The main contribution of this study is fourfold. First, it measures learning by FDI effects, extending previous empirical evidence on learning by other forms of internationalization, such as exporting. Second, the use of micro level data in the framework of a country such as Spain that has not developed a strong technological base but has several MNE abroad adds new arguments to explain the emergence of new multinational enterprises. Third, the capacity of firms to improve their productivity and compete locally through their internationalization extends in a new direction the standard strategic environment considered by the macroeconomic literature, where productivity improvements are the ones leading to the internationalization of firms. Fourth, the sequential improvements derived from the learning process of firms add a dynamic perspective to the entry environments considered when designing their corresponding internationalization strategies.

Finally, several implications are obtained for managers and policy makers regarding the promotion of FDI while taking into account the potential positive effects that can be derived from learning abroad.

The rest of the paper is organized as follows. The next section describes the literature background supporting our research. Section three develops the main hypotheses being tested. The fourth section contains the data description, while the fifth section is devoted to the empirical analysis. Finally, the last section discusses the main findings and implications derived from the analysis.

2 Literature background and hypothesis development

2.1 Firms heterogeneity

The contributions of the literature on firms' heterogeneity are based on Brainard's (1997) seminal model in which exports and horizontal FDI are considered as substitute strategies for firms' internationalization. The main prediction of the model is that the interaction of trade costs, market size and plant-level scale economies explain the choice between exports and FDI (Head and Ries 2003). Consequently, when the foreign market size and the costs of exporting increase, FDI is preferred over exporting, while FDI would be less favoured in the presence of higher production costs (Greenaway and Kneller 2007).

However, it is generally observed among the firms located within a given industry in a country that, *ceteris paribus*, some serve the domestic market, others export, and others use FDI to serve foreign markets. This equilibrium outcome is addressed by firms' heterogeneity models, in which some specific characteristics of the firms, such as sunk costs and productivity, are used to explain their participation in the export market, being the main prediction that only the most productive firms become exporters (Melitz 2003).

In this regard, the work by Helpman et al. (2004) -HMY model henceforth—connects the main characteristics of firms and their internationalization by both exports and horizontal FDI. Their model predicts that differences in productivity among firms determine whether a firm should serve the domestic market or engage in exporting or FDI activities. One of its main implications is the self-selection process taking place among heterogeneous firms, where only the most productive ones become MNE. Those firms with intermediate productivity levels become exporters and the less productive ones sell domestically (Melitz 2003).

Among the extensions of the HMY model, we highlight the following ones. Yeaple (2009) builds a model where the most productive firms invest in a larger number of foreign countries while the less productive ones serve only the most attractive country. Melitz and Ottaviano (2008) conclude that market size affects industry performance given the fact that larger markets exhibit tougher competition, resulting in lower average mark-ups and higher aggregate productivity. Engel and Procher (2012) show that the predictions of the HMY model apply only when considering market-driven FDI. Other works extend into different forms of international expansion and allow firms to choose between Greenfield FDI and M&A (Neary 2009; Raff et al. 2009), introducing the existence of mobile capabilities to justify internationalization through M&A (Nocke and Yeaple 2007).

Firms' heterogeneity models are supported by a substantial amount of empirical work. For example, Bernard and Bradford Jensen (1999) checked the relationship between the productivity level and the export status for a sample of US firms. They confirmed that exporter firms exhibit higher productivity levels than non-exporters within the same industry. Following this contribution, two main lines of research have been developed: the first one aims at explaining whether exporter and non-exporter firms differ in terms of productivity, while the second explores the causes and consequences of productivity differences between exporter and non-exporter firms (Wagner 2007). It should be highlighted that this pioneering evidence focused on productivity differences between domestic and exporter firms without considering foreign investor firms.

Additional empirical evidence exists for a variety of countries: Aw et al. (2000), Delgado et al. (2002), and Arnold and Hussinger (2005) have shown that exporter firms are more productive than non-exporters for a sample of Korean, Spanish, and German firms, respectively. Conversely, Greenaway et al. (2005) found much smaller differences in performance between exporters and non-exporters for a sample of Swedish firms.

At the same time, some studies have explored the complete internationalization framework developed in the HMY model and considered domestic, exporter and investor firms. In this line of research, the work of Girma et al. (2005) was one of the first analyses that added empirical evidence to the HMY model using a sample of UK firms. The authors found that MNE firms were more productive than exporter firms and the latter ones more productive than domestic firms. These results have also been supported by Head and Ries (2003) and Kimura and Kiyota (2006) for Japanese manufacturing firms and by Wagner (2006) for a sample of German firms.

Two different arguments have been proposed to explain the causes and consequences derived from these productivity differences among domestic, exporter and investor firms: firstly, authors generally assume that there is a self- selection process of the most productive firms. That is, the most productive firms go abroad given the fact that they are the only ones that can afford to pay the extra costs of the internationalization process. Secondly, expanding through internationalization allows for the acquisition of knowledge and, therefore, raises the productivity level of firms (Wagner 2007), being this phenomenon referred to as learning abroad or learning by exporting in the case of exports (Bernard and Bradford Jensen 1999).

The current research is indeed focused on this latter aspect, assuming that international firms show higher rates of productivity as a result of the learning abroad process. This line of research is relevant because the clear majority of studies have focused on the analysis of learning by exporting (Delgado et al. 2002; Salomon and Shaver 2005; Salomon and Jin 2007; Damijan et al. 2010; Silva et al. 2012; Love and Ganotakis 2013). The evidence on learning by exporting has shown a positive relationship between exporter firms and their level of productivity that can be explained through both the access of exporters to new sources of knowledge and the competitive pressure forcing firms to innovate to survive in the international market (Liu and Buck 2007).

However, other evidence confirms that learning by exporting has little effect on productivity growth, since its impact is dilated though time and, thus, cannot be immediately materialized in a productivity increase (Delgado et al. 2002; Arnold and Hussinger 2005; Salomon and Shaver 2005; Aw et al. 2007). Moreover, to check more specifically for learning by exporting effects, several authors have proposed the use of innovation variables as the black box that can contribute to explain differences in productivity levels before internationalization and the effects of learning after internationalization (Castellani and Zanfei 2007; Cassiman and Golovko 2010; Castellacci 2011; Monreal-Pérez et al. 2011; Belderbos et al. 2013).

2.2 Internationalization processes, learning and knowledge

The effect of internationalization on learning and the role of foreign knowledge as a source of competitive advantage constitute a particularly fruitful source of analysis in the IB literature (Buckley and Carter 1996; Mudambi and Navarra 2004; Ambos et al. 2006, Rabbiosi 2011). This branch of the literature builds on the behavioral theory models that recognize the capacity of firms to learn abroad (Cyert and March 1963) and the Uppsala model of gradual internationalization that connects the international commitments of firms with their experiential knowledge (Johanson and Wiedersheim-Paul 1975; Johanson and Vahlne 1977).

These theoretical environments predict a positive relationship between the type of international expansion strategy of the firms (including the entry modes used), and the number of countries targeted, which will be higher as the firms' international commitment increases (Jonsson and Foss 2011). Nonetheless, the recognition of generic learning effects in this type of models is limited since they do not consider the possibility of learning as a firm strategy. That is, the asset-augmenting strategy is missing from their theoretical propositions, even when the aforementioned studies recognize that FDI can be undertaken with the aim of acquiring knowledge abroad (Dunning and Narula 1995; Eriksson et al. 1997; Forsgren 2002).

A crucial aspect for understanding the learning effects derived from the internationalization process is the nature and extent of knowledge flows in the theory of MNEs. The most traditional studies in the field focus on the transference of knowledge between the headquarter unit (HQ) and the subsidiaries and how the latter adopt the knowledge of the corporation to particular locations (Dunning 1988; Vernon 1966). Moreover, a better understanding of the subsidiaries' competences and the learning possibilities in foreign locations has given place to models that consider how the new knowledge acquired by the subsidiaries in a foreign context can revert to the HQ and even to the rest of the MNE. These has been defined as reverse knowledge flows and contribute to a better definition of the subsidiaries' learning process (Håkanson and Nobel 2001; Mudambi 2002; Mudambi and Navarra 2004; Mudambi et al. 2013).

Several theoretical models have been developed to explain how subsidiaries may be conceived as a source of external knowledge for the MNE because of their key role in organizing decentralized R&D and the innovation process (Sanna-Randaccio and Veugelers 2007). This latter model has been extended in recent contributions that combine different entry modes (Greenfield FDI and M&A) and the potential reverse knowledge flows taking place between the HQ and the subsidiaries depending on the level of development of the foreign location (Alvarez et al. 2015).

At the same time, it has been suggested that the internationalization of firms may be considered as a source of new inputs for the innovation process and that, therefore, the knowledge acquired abroad can be transformed into new innovations (Hitt et al. 1997; Belderbos 2003; Yeoh 2004; Kafouros et al. 2008; Yang et al. 2008). The reasons for this assessment are related to the competitive pressures that firms face in foreign markets and how this can positively affect the development of innovations to defend their market shares. In this sense, it is important to note the difference between competence exploiting and competence creating subsidiaries since the corresponding expected knowledge flows may differ (Cantwell and Mudambi 2005). Moreover, internationalized firms may learn by incorporating global resources that become available because of their presence in different foreign countries, which facilitates their access to new knowledge resources as contacts are established with foreign suppliers, universities, and research centers (Kafouros et al. 2008).

The integration of foreign knowledge should therefore be considered as a source of competitive advantage that can generate innovations (Buckley and Carter 1996; Mudambi and Navarra 2004; Ambos et al. 2006; Rabbiosi 2011). There is also a potential learning effect derived from the access to foreign knowledge sources that may lead to the increase of firms' productivity (Coe and Helpman 1995; Griffith et al. 2006; Belderbos et al. 2013; Kafouros et al. 2012). All in all, the previous background allows us to affirm that firms may learn abroad through FDI. Nonetheless, these learning effects could be weakened by industry components and should not be observed immediately but through an incremental path defined for a reasonable period of time (Petersen et al. 2008).

3 Hypotheses development

The arguments presented above provide us with a consistent background for the development of our working hypotheses. The models and empirical evidence on firms' heterogeneity define the existing connection between the firms' international commitment and productivity, which allows us to introduce the learning by FDI hypothesis. Like exporter firms, those firms that perform FDI have access to new sources of knowledge. The resulting learning process should be reflected in an increasing amount of innovative outputs and an improved productivity level. Moreover, considering the relevance of the knowledge acquired abroad as a special source of competitive advantage for MNE firms, it seems plausible to assume that MNE firms are able to incorporate this knowledge in their production functions and that this type of behavior derives into positives results. Consequently, the resulting learning effects should depend both on the technological content of the industries involved and the level of development of the country hosting the FDI of the MNE.

Therefore, the main two hypotheses of this research are the following:

- First, subsidiary units can learn abroad and this process may be reflected in an increase of the innovative outputs of the MNE. In addition, given the fact that both learning and innovation can be defined as long-term processes, their temporal dimension should be accounted for and illustrated in the results. Thus, the first hypothesis states *that the MNE status of firms will positively affect their ex-post innovative outputs* (*H1*).

- The second hypothesis deals with the question of whether these learning effects are manifested in an ex-post increase of the firms' productivity levels. *Therefore, H2 states that the MNE status of firms will positively affect their level of productivity.*

In addition, robustness tests will be performed on both hypotheses by accounting for the technological content of the industries involved and the development level of the countries in which the FDI takes places.

Figure 2 shows graphically these two hypotheses together with their expected signs and the direction of the learning process.

The main consequences derived from the verification of our hypotheses extend into both the IB and macroeconomic literatures. Note that the capacity of firms to improve their productivity by performing FDI and compete locally afterwards extends the standard strategic environment considered by the macroeconomic literature on firms' heterogeneity in a new direction. Figure 3a illustrates the standard framework considered by the literature on firms' heterogeneity, where productivity improvements at the local level lead to the internationalization of firms. In this case, only the most productive local firms are able to afford the costs associated with the internationalization process. On the other hand, Fig. 3b describes the FDI-driven increment in productivity that follows from our hypotheses. In this case, local firms performing FDI can achieve an increase in productivity that endows them with a competitive advantage over previously productive exporters and other local firms.

Moreover, the sequential improvements derived from the learning process of MNE firms add a dynamic perspective to the different entry environments considered when designing their corresponding internationalization strategies. In this regard, our hypotheses open a temporal dimension in the internationalization and entry mode scenarios analyzed by the IB literature. Figure 4 illustrates the main dynamic implications following from the learning process of MNEs. In this case, a temporal dimension must be added to the geographical one considered by the IB literature when evaluating the knowledge spillovers expected to be received and the resulting entry strategies of the MNE firms.

4 Features of the sample and data description

The analysis presented through the rest of the paper is performed on Spanish manufacturing firms. The data have been retrieved from the *Encuesta de Estrategias Empresariales*-ESEE (Business Strategies Survey) for a period of 10 years, from 2000 to 2009. The

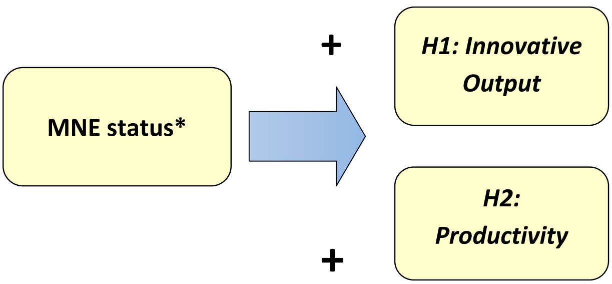

Fig. 2 The learning effects hypothesis. Both hypotheses are tested considering the technological sector of the MNE and the income level of the country where the FDI takes place

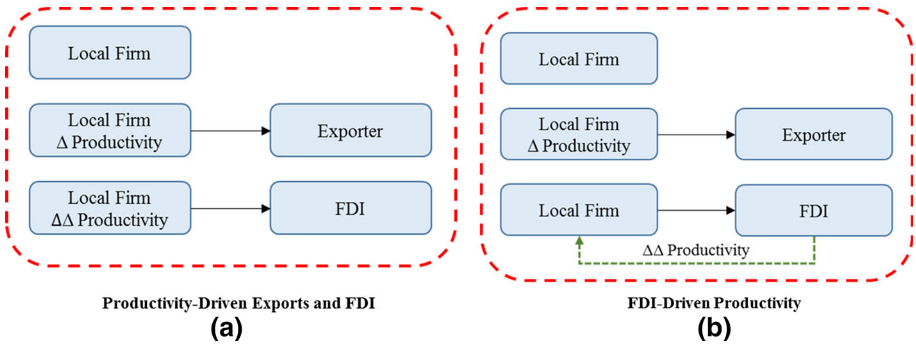

Fig. 3 Productivity-driven FDI versus FDI-driven productivity. **a** Standard framework. **b** Learning effects hypothesis

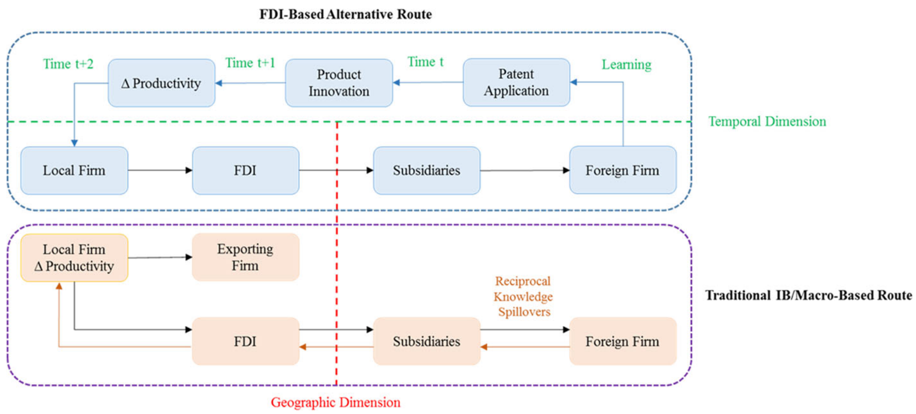

Fig. 4 Dynamic implications derived from the learning process of MNEs

ESEE survey is elaborated annually by the Fundación SEPI and the Spanish Ministry of Economy and Competitiveness since 1990 and it presents a panel of Spanish manufacturing firms with more than 10 employees. The initial panel considered is composed by 17,870 observations per variable, which correspond to 1787 firms during a period of 10 years. This dataset contains detailed information on innovation and internationalization activities—such as exports and foreign establishment activity, which is the reason why the MNE status of firms can be studied. Additional information about this dataset can be found in Álvarez (2003) and Rodríguez (2010).

The data referring to the MNE status of firms were introduced in the survey starting in 2000. In particular, the dataset contains information on whether the firm invests in foreign markets as well as the percentage of participation in foreign companies. We constrain our analysis to the cases where the participation in the equity capital of a foreign firm is superior to 10%. This criterion has been adopted following the established definition of FDI in the IMF's V Balance of Payments Manual. In addition, it has been largely used in the IB literature (Yeaple 2009; Engel and Procher 2012).

Given that we aim at analyzing the effect that the MNE status of Spanish firms has on their innovative output and productivity levels, the sample has been further restricted to those firms that report at least 4 consecutive years of MNE status. This criterion allows us to avoid possible sample noise. According to this last restriction, 342 firms are endowed with the MNE status, which represents roughly 19.14% of the total firms in the sample.

The usefulness of this dataset has been verified in several previous contributions to the literature that analyze the relationship between the innovative behavior of Spanish firms and their internationalization activities (Delgado et al. 2002; Alvarez and Molero 2005; Salomon and Jin 2007; Marin and Alvarez 2009; Cassiman and Golovko 2010; Monreal-Pérez et al. 2011; Triguero and Córcoles 2012; García et al. 2012; Esteve-Pérez and Rodríguez 2013). However, with the exception of Almodóvar et al. (2009) and Almodóvar and Rugman (2013), who consider the same sample of Spanish MNE firms, the available dataset has not been used to perform an analysis similar to the one in this paper.

Regarding the emergence of Spanish MNEs in the last decades, it should be mentioned that the number of firms with this status has increased by 37% in the ESEE through the period analyzed. The relevance of MNEs in the sample can be observed in Table 1, where MNE firms are shown to represent a considerable proportion among some performance variables such as added value (57.70%), sales (57.72%), exports (65.65%), employment (54.56%) and R&D Expenditure (75.41%). This last value indicates that MNE firms account for more than three quarters of the total Spanish Business R&D expenditure in aggregate terms.

Table 2 shows that the technological sector in which MNE firms are more active is medium tech industries (MTECH). That is, 55.28% of the Spanish MNEs in our sample belong to MTECH, while only 16.01% of them are high tech (HTECH) and 28.70% of them are in low tech industries (LTECH). On the other hand, domestic firms have a stronger presence in both medium and low tech industries, with percentages of 49.41 and 47.79%, respectively.

We have approximated the relationship between the firms' productivity levels and their international commitment using the indicator of relative Value Added (value added as a percentage of sales). Figure 5 shows that MNE firms have higher productivity levels on average than their domestic counterparts. This figure also shows that productivity levels are higher among exporters than in domestic firms, which confirms the arguments underlined by the firms' heterogeneity models presented in the previous section. Moreover, considering the index of relative productivity built between MNE, domestic and exporter firms, the values presented in Table 3 illustrate the superiority of MNEs in terms of productivity not only with respect to domestic firms but also over exporters.

The description of the data presented above shows a relationship between the incremental international commitment of Spanish manufacturing firms and their larger productivity levels. However, we should consider the causality direction of this relationship cautiously, i.e. whether productivity encourages internationalization or if it is the internationalization commitment of firms what encourages productivity, or, further, whether there is a combined action of the two that is defined by a feedback process.

Regarding the main technological variables, Table 4 shows that Spanish MNEs report higher average values compared to exporter and domestic firms. MNE firms exhibit a

Table 1 Spanish MNE firms as a percentage of total firms in the sample (average values for the period 2000–2009)

Firms	Added value	Sales	Exports	Employment	Expenditure R&D
19.14	57.70	57.72	65.65	54.56	75.41

Table 2 Percentage distribution of MNE and domestic firms by technological content (average values for the period 2000–2009)

	HTECH	MTECH	LTECH
M	16.01	55.28	28.70
D	2.784	49.41	47.79

Division of industries according to the OCDE Classification Rev. 3 is included in the Appendix Table 13 (M = MNE; D = Domestic)

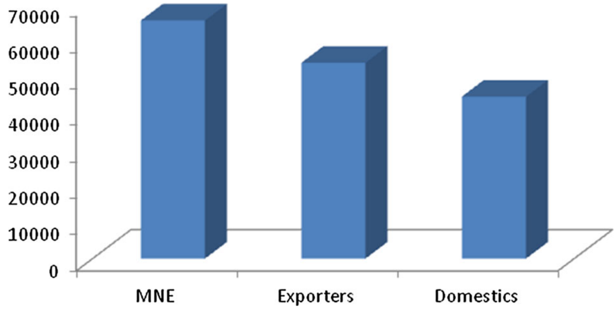

Fig. 5 Productivity levels in domestic, exporter and MNE firms in the period 2000–2009 (thousands of euros)

Table 3 Index of relative productivity

Index of relative productivity	
MNE/domestic	1.470950302
MNE/exporter	1.216349208

Value in means of the total MNE-X-D

Table 4 Technological indicators of Spanish manufacturing firms (average values for 2009)

	Num. patents Spain (per employee)	Num. patents abroad (per employee)	Product innovation (per employee)	R&D personnel (per employee)	R&D intensity (R&D exp/ sales)
MNE	0.198	0.281	0.837	1.735	2.020
Exporters	0.141	0.092	1.943	1.206	1.225
Domestics	0.003	0.019	0.338	0.218	0.138

higher propensity to patent both in Spain and abroad. Moreover, MNE firms display higher values in the indicators of R&D personnel and R&D intensity (in relation to sales). Finally, note that the group of exporter firms outperforms the others when considering product innovation.

5 The effects of learning by FDI

5.1 Differences between domestic and MNE firms

Table 5 presents the results obtained using discriminant analysis to illustrate the technological differences existing between the international commitment of firms and their technological performance. MNEs differ from domestic firms when considering the main technological variables and the question is whether these differences can be explained, and to what extent, by the MNE status of the firm. Moreover, a deeper analysis of this relationship requires considering the technological content of industries, which has led to the division of the sample into high, medium and low tech content. This sectorial classification has been implemented following the OCDE Classification Rev.3, which is included in Table 13 of the "Appendix" section.

The results derived from the discriminant analysis performed on the whole sample reveal that patents in Spain, product innovations and R&D personnel are the variables that better differentiate between domestic and MNE firms in the entire sample. In particular, all these variables increase when firms become MNEs. Moreover, when the technological content of the industries is taken into account, R&D intensity and product innovations are the key aspects differing between both types of firms in HTECH. At the same time, patents in Spain, patents abroad, product innovations and R&D personnel are all crucial to differentiate between domestic and MNE firms in the medium tech subsample. Finally, patents in Spain and personnel in R&D differentiate domestic and MNE firms in LTECH.

These results provide intuition regarding the patenting strategy of the MNE firms in the respective host economies and the learning abroad effect derived from their MNE status. Note that when considering the whole sample, MNEs apply for a larger amount of patents

Table 5 Differences in technological indicators between MNE and domestic firms

Variables	All sample	High tech content	Medium tech content	Low tech content
R&D intensity	n.s	0.896***	n.s	n.s
Patent Spain	0.612***	n.s	0.392**	0.858***
Patent abroad	n.s	n.s	0.372***	n.s
Product innovation	0.608***	0.491***	0307***	n.s
Personal in R&D	0.246***	n.s	0.542***	0.523***
Chi Squared	118.391	16.735	57.076	50.975
No. observation	1783	171	883	649
Cases rightly classified	79%	68%	77%	82%
Wilk's lambda	0.936	0.905	0.935	0.924
Group of centroids				
Domestic	−1.27	−0.216	−0.132	−0.118
MNE	0.54	0.48	0.506	0.691

Dataset used is composed by the average value of the variables in the period (2000–2009)

Stepwise Discriminant Function Analysis

n.s: variable not significant in the discriminant function between Domestic and MNE firms

*** 99% Confidence level (p value, F-test)

** 95% Confidence level (p value, F-test) in Spain but not abroad. This result could reflect the effect that the knowledge acquired abroad has on the innovative output of the MNEs at home. At the same time, those MNEs operating within a MTECH environment exhibit an increment in their number of patents both in Spain and abroad. This latter phenomenon describes a potential defensive strategy on the side of the MNEs when operating in a foreign country and protecting their intellectual property through additional patent applications. Thus, to account for this strategic defensive mechanism, we will explicitly differentiate between the patent applications taking place in Spain and abroad when analyzing the learning effects derived from the MNE status of firms.

It should be highlighted that the increase in the value of the group of centroids when shifting from domestic to MNE firms implies that the technological profile of firms increases with their level of international commitment. This is the case for the whole sample as well as for all the industry groups, which denotes the possibility of learning abroad effects.

These results allow us to justify the use of two different measures of innovative outputs—patents and product innovations—in our analysis of the effects of the MNE status on the innovative results of firms, an aspect to which the next section of the paper is devoted.

5.2 The econometric model

We start by testing our first working hypothesis—the effects of the MNE status of firms on their ex-post innovative outputs. Given the fact that a lapse of time may be required to observe these effects, we implement the Generalized Method of Moments (GMM) for dynamic panel data with a lag structure. The following equation defines the relation being estimated:

$$Y_{it} = \beta_0 + \beta_1 Y_{it-1} + \beta_2 MNE_{i,t-p} + V_{it} + \eta_{si} + \upsilon_{dt} + \varepsilon_{it} \tag{1}$$

where the sub index i stands for the firm, $p = 1, 2$ is used to introduce the two-period time lag, Y_{it} corresponds to the innovative outputs—product innovations ($INNO_{it}$) and patent applications made either in Spain (Pt_{it}) or both in Spain and any foreign location (Pat_{it}), Y_{it-1} is the lag of the dependent variable, which endows the model with a dynamic structure, $MNE_{i,t-p}$ accounts for the MNE status of firm i at time $t-p$, V_{it} is a vector of other explanatory variables affecting the innovative output of firms, and η_{si}, υ_{dt} and ε_{it} correspond to specificities of the technique being used and represent individual and time effects, and the random error term, respectively.

The use of technological variables to capture the effects of learning abroad has already been justified by other authors in the literature (Salomon and Shaver 2005; Castellani and Zanfei 2007; Salomon and Jin 2007; Silva et al. 2012). The main building arguments of our model are based on the fact that learning effects are not immediately materialized in an increase of productivity and that the latter is a rough measure of learning outcomes due to its heterogeneity among firms. However, it is possible to observe some learning patterns through the direct analysis of technological outputs. Consequently, the use of innovative outputs such as patent applications and product innovations as a proxy to measure learning effects has gained considerable relevance since these variables allow to observe learning in a more direct way than productivity (Salomon and Shaver 2005; Castellani and Zanfei 2007; Salomon and Jin 2007; Silva et al. 2012). In this regard, we have introduced the lagged dependent variable Y_{it-1} to reflect the dynamic structure of the model, avoid endogeneity problems and account for the effect that previous productivity or innovative outputs may have on their current level, as argued by Bernard and Bradford Jensen (1999). Note that patents have also been used as a measure of knowledge flows between different units of the MNE network (Mudambi and Navarra 2004).

The MNE status of firms is our main independent variable. This variable is a dummy that captures whether or not firms have direct investments in foreign markets. Thus, this measure will take the value 1 whenever firms are present in foreign countries and the value 0 otherwise. We have considered the entire sample to avoid any potential bias while the analysis is constrained to firms that report being MNEs. Note that we have to take into account the lagged MNE status of firms ($MNE_{i,t-1}$,$MNE_{i,t-2}$) to test whether or not it affects their current innovative output and productivity. Accounting for this lagged variable is in accordance with the period of time required for learning effects to be observed in the innovation activities of firms (Salomon and Jin 2007; Golovko and Valentini 2011). These authors also conclude that the amount of time required is even larger when considering productivity. Therefore, the time required for the assimilation of knowledge is a relevant dimension in this type of analysis (Aw et al. 2000).

As already stated, to test our second working hypothesis—the effect of the MNE status on ex-post productivity levels -, we define value added divided by sales as a proxy for productivity. This proxy constitutes a simple way of measuring productivity that has already been used in several other works such as Castellani and Zanfei (2007) and Esteve-Pérez and Rodríguez (2013). Thus, our second hypothesis estimation takes productivity as the dependent variable Y_{it} in Eq. (1).

Regarding our first robustness test, we analyze whether or not the MNE status and, therefore, the acquisition of knowledge abroad is conditioned by the technological content of the industrial sector in which the firm operates. The following equation defines the relation being estimated:

$$Y_{it} = \beta_0 + \beta_1 Y_{it-1} + \beta_2 MNE * TechSector_{it-p} + V_{it} + \eta_{si} + \upsilon_{dt} + \varepsilon_{it} \quad (2)$$

where the sub index i stands for the firm and $p = 1, 2$ is used to introduce the two-period time lag. The main difference between this equation and Eq. (1) is the variable $MNE * TechSector_{it-p}$, which accounts for the MNEs operating in high tech (MNEHTECH), medium tech (MNEMTECH) and low tech (MNELTECH) sectors.

We perform a second robustness test by differentiating the countries in which the FDI takes place according to their relative level of development. That is, we categorize the host countries within High, Medium and Low-income groups following the corresponding World Bank classification.[1] In this regard, the dataset classifies the FDI destination in four main categories, namely, OECD, European countries, Latin American countries and rest of the world. We generate two variables, MNEHOSTHM, which accounts for the MNE status of firms when the destination of their FDI is either a high or a medium income country (OECD and Europe), and MNEHOSTL, which applies when the destination is a low-income country (Latin America and rest of the world). The following equation defines the relation being estimated:

$$Y_{it} = \beta_0 + \beta_1 Y_{it-1} + \beta_2 MNEHost_{it-p} + V_{it} + \eta_{si} + \upsilon_{dt} + \varepsilon_{it} \quad (3)$$

where the sub index i stands for the firm and $p = 1, 2$ is used to introduce the two-period time lag. The main difference between this equation and Eqs. (1) and (2) is the variable

[1] https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups.

$MNEHost_{it-p}$, which accounts for the MNEs whose FDI is in either a high/medium income country (MNEHOSTHM) or a low-income one (MNEHOSTL).

We have defined the firms' R&D intensity and size as control variables in all the estimations. These variables have been used to analyze the effects derived from firms' heterogeneity in several other studies (Greenaway and Kneller 2007). R&D intensity is considered an important variable for the assimilation and transformation of knowledge acquired abroad because it allows firms to build a minimum level of absorptive capacity (Cohen and Levinthal 1990). In this sense, authors such as Greenaway and Kneller (2007) have recognized the relevance of R&D for the materialization of new knowledge since the higher the absorptive capacity of firms the higher the expected benefits derived from the MNE status (Ambos et al. 2006; Aw et al. 2007; Golovko and Valentini 2011; Kafouros et al. 2012). Therefore, the expenditure on R&D facilitates knowledge transfers and allows firms to increase the amount of knowledge received while absorbing and transforming it into innovation outputs. Moreover, the association between R&D and innovative outputs has been extensively analyzed in the literature together with the combination process of external and internal knowledge (R&D) aimed at enhancing the productivity growth of firms (Salomon and Shaver 2005; Golovko and Valentini 2011; Triguero and Córcoles 2012).

We also consider size as a structural characteristic of firms. This variable has been traditionally used in diverse studies on internationalization and innovation (Alvarez and Molero 2005; Salomon and Jin 2007; Cassiman and Golovko 2010; Triguero and Córcoles 2012). The evidence presented in these papers shows that MNEs are more likely to be large firms and that these firms are generally more productive than exporter or domestic firms (Bernard and Bradford Jensen 1999; Tomiura 2007; Yeaple 2009). It has also been argued that a positive relationship exists between firms' size and innovative outputs and productivity levels (Dosi 1992; Salomon and Shaver 2005; Triguero and Córcoles 2012).

Table 6 summarizes all the variables described above together with their definitions.

Finally, regarding the methodology, dynamic panel data analysis is performed. This methodology is adequate because it allows us to deal with the inherent endogeneity of the model. In other words, it takes into account the path dependent trajectory or cumulative process that characterizes the innovation process (Dosi 1988; Castellacci 2008). Moreover, this method allows us to consider the lags of the independent variables, which are essential for measuring learning abroad effects. This is the case since, as it has been previously argued, these effects are not manifested immediately in terms of innovative outputs or productivity increments.

Other additional advantages of this method given our research question are firstly, that effects taking place over time are included in the model and, secondly, that it is possible to account for individual (i.e., firm) effects following a dynamic perspective. The Generalized Method of Moments uses first difference transformations to deal with the endogeneity of the variables. It does so by considering all the available lags as instruments to avoid possible correlations with the individual effects (Arellano and Bond 1991; Arellano and Bover 1995; Roodman 2006; Roodman 2009).

The dynamic panel data estimations of the learning effects on innovative outputs are presented in Table 7, while the learning effects on productivity are analyzed in Table 8. The robustness test by technological industries is described in Table 9 and the analysis considering the level of development/income of the host countries is provided in Tables 10, 11 and 12. The correlation matrices for the variables used in the model can be found in Tables 14 and 15 of the "Appendix" section. We will analyze the results presented in each one of these tables throughout the following sections.

Table 6 Summary of the variables used in the analysis of learning effects

Dependent variables	
Est. 1: $INNO_{it}$	Number of product innovations, firm i year t
Est. 2: Pt_{it}	Number of patents in Spain, firm i year t
Est. 2': Pat_{it}	Number of patent applications made in Spain and in foreign countries, firm i year t
Est. 3: Productivity Pd_{it}	Ln of productivity (Value Added/Sales), firm i year t
Independent variables	
$MNE_{i,t-p}$	Dummy variable that takes the value (1) if the % of participation in the social capital of foreign firms is >10%, (0) otherwise
MNE (HTECH, MTECH, LTECH)	MNE classified according to the technological sector of operation: high (HTECH), medium (MTECH) or low (LTECH)
MNE (HOSTHM, HOSTL)	MNE classified according to the income/development level of the host country. It considers MNE operating in High or Medium income host countries (MNEHOSTHM) and MNE operating in low-income countries (MNEHOSTL)
Control variables	
Rd_{it}	Ln R&D intensity (R&D expenditures divided by sales)
$Size_{it}$	Ln total employees

Table 7 Learning effects on innovative outputs

	Pt_{it}		Pat_{it}		$INNO_{it}$	
	(1)	(2)	(3)	(4)	(5)	(6)
Y_{t-1}	0.412***	0.392***	0.662***	0.647***	0.831***	0.830***
	(0.126)	(0.135)	(0.084)	(0.084)	(0.0456)	(0.0493)
MNE_{t-1}	0.255***		0.042***		−0.735	
	(0.087)		(0.014)		(0.5753)	
MNE_{t-2}		0.256***		0.051***		0.403**
		(0.094)		(0.018)		(0.1618)
Rd	0.067*	0.065*	0.017***	0.021***	0.87**	0.278*
	(0.035)	(0.037)	(0.005)	(0.005)	(0.14)	(0.1773)
Size	0.046*	0.052**	0.014***	0.016***	0.028	−0.492
	(0.027)	(0.026)	(0.004)	(0.004)	(0.5358)	(0.3069)
_cons	−0.151	−0.183	−0.040**	−0.041**	0.189	2.718
	(0.123)	(0.116)	(0.017)	(0.019)	(2.8)	(1.7322)
Ar(1)	−2.34**	−2.30**	−6.60***	−5.95***	−1.91**	−1.71**
Ar(2)	0.339	−0.93	0.53	−0.62	0.62	0.64
Hansen Chi^2	4.8	5.17	3.35	3.12	89.55	7.,9
Observations	3404	3244	4335	4737	4174	3595

GMM-two step. Robust standard errors in parentheses (Roodman 2012)

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

Table 8 Learning effects on productivity

Pd_{it}		
	(1)	(2)
Pd_{t-1}	0.191***	0.193***
	(0.041)	(0.048)
MNE_{t-1}	0.018	
	(0.050)	
MNE_{t-2}		0.177***
		(0.050)
Rd	−0.050***	−0.054
	(0.015)	(0.041)
Size	0.099*	0.069***
	(0.051)	(0.015)
_cons	8.242***	8.340***
	(0.529)	(0.506)
Ar(1)	−5.64***	−6.16***
Ar(2)	2.03	1.78
Hansen Chi^2	169	79.62
Observations	4314	3706

GMM-two step. Robust standard errors in parentheses (Roodman 2012)

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

5.3 Empirical analysis

The results of the first panel data estimation presented in Table 7 illustrate the existence of a learning process on innovative outputs that benefits internationalized firms through FDI. It can be observed that the coefficient of lagged MNE status is positive and significant in all cases, which implies that the MNE status of firms affects positively their ex-post innovative outputs. Sequential learning by FDI is confirmed given the fact that the MNE status at $t - 1$ and $t - 2$ affects the current volume of patent applications made in Spain (Pt_{it}) and product innovations. That is, firms with a MNE status apply for a larger number of patents at home and exhibit a larger amount of product innovations. At the same time, the defensive mechanism implemented by the MNEs performing FDI can be observed when considering both Spanish and foreign patent applications (Pat_{it}). In this case, the lagged MNE status of firms leads to an increment in the number of patent applications both in Spain and in the foreign locations. Moreover, the correlation analysis between the dependent variables and the lags of the MNE status shows a positive relationship (Table 15 in the "Appendix" section), a feature that is also consistent with the existence of learning by FDI effects.

Note that different results are obtained for the two innovation indicators considered. In particular, when patents are taken as the dependent variable (Columns 1 to 4 in Table 7), the previous MNE status affects positively the current level of patent applications. Besides, these effects increase sequentially through time following the entrance of the firm in a foreign market (i.e. the coefficient of this variable increases with the number of lags). This implies that the innovative gap between MNEs and domestic firms may also increase over time. However, when product innovation is the indicator taken as the dependent variable (Columns 5 and 6 in Table 7), the MNE status of the firm becomes significant only after a 2-years lag. This implies that the ex-post effects of the MNE status take longer to

Table 9 Learning effects by the technological content of industries

	Pt_{it}					
	(1)	(2)	(3)	(4)	(5)	(6)
Y_{t-1}	0.429***	0.424***	0.316***	0.319***	0.412***	0.391***
	(0.106)	(0.116)	(0.900)	(0.093)	(0.125)	(0.135)
$MNEHTECH_{t-1}$	0.571*					
	(0.307)					
$MNEHTECH_{t-2}$		0.678*				
		(0.369)				
$MNEMTECH_{t-1}$			0.124			
			(0.079)			
$MNEMTECH_{t-2}$				0.108		
				(0.079)		
$MNELTECH_{t-1}$					0.048	
					(0.129)	
$MNEHTECH_{t-2}$						0.096
						(0.140)
Rd	0.058**	0.055**	0.052**	0.057***	0.061*	0.060
	(0.025)	(0.026)	(0.021)	(0.021)	(0.036)	(0.038)
Size	0.069**	0.074***	0.041*	0.046**	0.075**	0.076**
	(0.028)	(0.027)	(0.023)	(0.023)	(0.032)	(0.032)
_cons	−0.224*	−0.261**	−0.126	−0.151	−0.237*	−0.243*
	(0.126)	(0.120)	(0.110)	(0.104)	(0.138)	(0.136)
Ar(1)	−2.48**	−2.54**	−2.10**	−2.11**	−2.34**	−2.29
Ar(2)	−0.93	−0.96	−0.95	−0.92	−0.94	−0.93
Hansen Chi^2	3.37	3.28	35.04	34.6	4.72	5.18
Observations	3244	3404	3404	3244	3404	3244

Table 9 continued

	Pat_{it}						$INNO_{it}$		
	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Y_{t-1}	0.382***	0.340***	0.490***	0.003	0.387***	0.317***	0.819***	0.834***	0.805***
	(0.040)	(0.045)	(0.041)	(0.071)	(0.040)	(0.044)	(0.050)	(0.049)	(0.052)
$MNEHTECH_{t-1}$	0.106**								
	(0.041)								
$MNEHTECH_{t-2}$		0.132**					0.012		
		(0.057)					(0.594)		
$MNEMTECH_{t-1}$			0.052**						
			(0.022)						
$MNEMTECH_{t-2}$				0.094*				0.503*	
				(0.056)				(0.298)	
$MNELTECH_{t-1}$					0.018				
					(0.024)				
$MNEHTECH_{t-2}$						0.033			0.476
						(0.031)			(1.153)
Rd	0.022***	0.026***	0.019***	0.038***	0.021***	0.027***	0.176	0.302*	0.178
	(0.004)	(0.005)	(0.005)	(0.011)	(0.005)	(0.006)	(0.290)	(0.180)	(0.300)
Size	0.023***	0.027***	0.015***	0.029***	0.024***	0.029***	−0.895	−0.537	−2.292
	(0.005)	(0.005)	(0.005)	(0.011)	(0.005)	(0.006)	(0.959)	(0.499)	(1.577)
_cons	−0.057**	−0.065**	−0.032	−0.109**	−0.058**	−0.067**	5.166	3.027	12.551
	(0.023)	(0.027)	(0.023)	(0.051)	(0.024)	(0.030)	(5097)	(2.701)	(8.456)
Ar(1)	9.94***	−8.56***	−9.23***	−4.17***	−9.79***	−8.58***	−1.70**	−1.72**	−1.69**

Table 9 continued

	Pat_{it}						$INNO_{it}$		
	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Ar(2)	−0.31	−1.5	0.17	−3.57	−0.28	−1.52	0.65	0.64	0.65
Hansen Chi^2	18.05	16.5	55.75	86.19	21.38	12..57	69.49	66.88	81.64
Observations	4335	4335	4335	3724	4335	3724	3595	3595	3595

GMM-two step. Robust standard errors in parentheses (Roodman 2012)

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

Table 10 Learning effects on innovative output by host country income

	Pt_{it}				Pat_{it}				$INNO_{it}$			
	Host high medium		Host low		Host high medium		Host low		Host high medium		Host low	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Y_{t-1}	0.197***	0.198***	0.201***	0.422***	0.648***	0.381***	0.686***	0.384***	0.854***	0.806***	0.853***	0.733***
	(0.047)	(0.047)	(0.047)	(0.101)	(0.083)	(0.035)	(0.085)	(0.040)	(0.031)	(0.149)	(0.032)	(0.101)
$MNEHOSTHM_{t-1}$	0.386***				0.044***				0.283			
	(0.139)				(0.016)				(0.428)			
$MNEHOSTHM_{t-2}$		0.440***				0.090***				0.6683*		
		(0.165)				(0.025)				(0.429)		
$MNEHOSTL_{t-1}$			0.006				0.007				−0.223	
			(0.166)				(0.046)				(0.482)	
$MNEHOSTL_{t-2}$				−0.168				0.008				−0.204
				(0.198)				(0.037)				(0.434)
Rd	0.109**	0.106**	−0.168	0.060**	0.019***	0.033***	0.018***	0.030***	0.264**	−0.361	0.288**	0.287*
	(0.047)	(0.047)	(0.198)	(0.125)	(0.005)	(0.005)	(0.005)	(0.006)	(0.124)	(0.494)	(0.142)	(0.174)
Size	0.057**	0.053*	0.057**	0.078***	0.014***	0.022***	0.017***	0.026***	−0.062	−0.047	−0.068	0.133
	(0.027)	(0.027)	(0.028)	(0.029)	(0.006)	(0.006)	(0.005)	(0.006)	(0.436)	(0.062)	(0.499)	(0.437)
_cons	−0.168	−0.155	−0.145	−0.241*	−0.028	−0.041	−0.038*	−0.054*	0.371	0.402	0.532	−0.203
	(0.141)	(0.142)	(0.135)	(0.125)	(0.018)	(0.028)	(0.020)	(0.030)	(2.258)	(0.421)	(2.649)	(2.412)
Ar(1)	−2.29**	−2.26**	−2.23**	−2.47**	−6.710***	−10.390***	−6.95***	−9.64***	−1.92**	−1,67**	−1.96**	−1.96**
Ar(2)	−0.95	−0.95	−0.95	−0.960	0.87	−0.77	0.91	−0.75	0.62	0.64	0.620	0.680
Hansen Chi^2	10.22	10.47	26.37	9.820	3.06	3.66	4.09	29.19	89.1	30.97	85.98	53.28
Observations	3404	3404	3404	3404	4517	4058	4517	4058	4179	2746	4.179	4.179

GMM-two step. Robust standard errors in parentheses (Roodman 2012)

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

Table 11 Learning effects on productivity by host country income

Pd_{it}	Host high and medium		Host low	
	(1)	(2)	(3)	(4)
Y_{t-1}	0.355***	0.039***	0.354***	0.038***
	(0.027)	(0.011)	(0.027)	(0.010)
$MNEHOSTHM_{t-1}$	0.010			
	(0.035)			
$MNEHOSTHM_{t-2}$		0.091**		
		(0.039)		
$MNEHOSTL_{t-1}$			−0.038	
			(0.048)	
$MNEHOSTL_{t-2}$				0.015
				(0.049)
Rd	0.100**	0.020	0.105**	0.020
	(0.042)	(0.034)	(0.044)	(0.036)
Size	−0.023*	−0.062***	−0.019	−0.055***
	(0.014)	(0.014)	(0.014)	(0.014)
_cons	−0.650***	−0.881***	−0.664***	−0.901***
	(0.072)	(0.075)	(0.073)	(0.075)
Ar(1)	−7.91***	−6.19***	−7.91***	−6,18***
Ar(2)	2.2	1.53	2.22	1.53
Hansen Chi^2	341.52	79.8	340	319
Observations	4297	3847	4297	3847

GMM-two step. Robust standard errors in parentheses (Roodman 2012)

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

materialize for product innovations than for patent applications. *H1* is therefore confirmed, even when some differences across the dependent variables are found.

These estimations also show that previous innovative outputs affect the current level of patents and product innovation. This is in line with innovation theory and with the idea that innovative experience plays a key role in the firms' current innovation level. Moreover, our control variables behave as expected: R&D intensity affects positively the number of product innovations and patent applications, and the coefficient of firms' size is positive and significant for the estimation of patents but it does not have any effect on product innovations.

5.4 Learning effects on productivity

Our second hypothesis tests the effect that the MNE status of firms has on their productivity. To do so, we replicate the model used in the previous estimations. The results are presented in Table 8.

The coefficient of the MNE status variable shows that there are not ex-post effects on productivity when the variable is lagged 1 year. However, when a second lagged period is considered, a positive effect is obtained. Thus, as was the case for product innovation,

Table 12 Learning effects on Pat_{it} by host country income and the technological content of industries

	Htech		Mtech		Ltech		Htech		Mtech		Ltech	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Y_{t-1}	0.518***	0.459***	0.394***	0.443***	0.655***	0.591***	0.503***	0.431***	0.402***	0.447***	0.662***	0.589***
	(0.048)	(0.024)	(0.042)	(0.010)	(0.097)	(0.106)	(0.047)	(0.025)	(0.041)	(0.014)	(0.098)	(0.112)
$MNEHTECH_{t-1}$	0.218*						0.103					
	(0.132)						(0.164)					
$MNEHTECH_{t-2}$		0.140***						0.118***				
		(0.010)						(0.031)				
$MNEMTECH_{t-1}$			0.256**						0.289***			
			(0.103)						(0.109)			
$MNEMTECH_{t-2}$				0.014**						0.055**		
				(0.005)						(0.024)		
$MNELTECH_{t-1}$					−0.213						−0.241	
					(0.326)						(0.358)	
$MNEHTECH_{t-2}$						−0.441						−0.497
						(0.414)						(0.476)
Host HM	0.046	0.039**	0.119***	0.039***	0.038	0.052						
	(0.031)	(0.019)	(0.041)	(0.015)	(0.027)	(0.035)						
Host L							0.060	0.027	−0.011	0.060***	0.035	0.044
							(0.054)	(0.021)	(0.043)	(0.017)	(0.026)	(0.038)
Rd	0.002	0.011***	0.008	0.022***	0.042**	0.049**	0.010	0.014***	0.009	0.026***	0.039*	0.048*
	(0.008)	(0.004)	(0.008)	(0.004)	(0.021)	(0.025)	(0.010)	(0.004)	(0.008)	(0.007)	(0.021)	(0.025)
Size	0.010*	0.014***	0.003	0.016***	0.009	0.004	0.012**	0.018***	0.017**	0.017***	0.009	0.005
	−0.006	−0.005	−0.007	−0.004	−0.014	(0.018)	(0.006)	(0.005)	(0.008)	(0.005)	(0.014)	(0.019)
_cons	−0.051	−0.055**	−0.047	−0.043**	0.041	0.136	−0.038	−0.061***	−0.124***	−0.092***	0.052	0.154
	(0.034)	(0.023)	(0.033)	(0.021)	(0.155)	(0.196)	(0.039)	(0.023)	(0.042)	(0.033)	(0.167)	(0.221)

Table 12 continued

	Htech		Mtech		Ltech		Htech		Mtech		Ltech	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Ar(1)	−9.06***	−8.70***	−9.48***	−8.29***	−6.68	−5.73***	−9.09***	−8.51	−9,52***	−8.44***	−6.82***	−5.48***
Ar(2)	0.28	−1.150	−0.23	−1.18	0.63	−0.77	0.24	1.22	−0.19	−1.13	0.64	−0.75
Hansen	179.91	108.740	44.5	105.91	77.62	76.84	71.22	110,54	39,68	113.16	77.020	76.,200
Observations	4346	3.731	4346	3731	4346	3745	4346	3731	4346	3731	4346	3745

GMM-two step. Robust standard errors in parentheses (Roodman 2012)

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

learning effects by FDI on productivity are not immediately observable but a reasonable time lapse is required for them to materialize. In this regard, the positive correlation between productivity and the MNE lag structure (Table 15 in the "Appendix" section) is also consistent with the learning by FDI process.

These results confirm our second hypothesis (*H2*), while being necessary to underline their temporal dimension to adequately interpret our findings. Moreover, when considering the control variables, R&D expenditures exhibit a negative relationship with productivity while the size coefficient is positive. This last result implies that it is more likely to find productivity improvements in larger firms. At the same time, knowledge generation and absorptive capacities are more developed among those firms investing intensely in R&D activities. This is also the case within the domestic context, which weakens the potential benefits derived from learning abroad.

5.5 Robustness test: learning effects by technological sectors

Our previous findings described in Table 7 allow us to confirm that firms learn abroad and that this process can be manifested in ex-post innovative results. Nonetheless, differences exist between industries in terms of learning possibilities. This is the reason why we replicate the analysis performed in the previous section dividing the MNE status variable according to the level of technological content of industries. The results obtained from the estimations are presented in Table 9.

When considering patent applications in Spain, our results show that the previous MNE status affects positively the current level of patent applications in high tech industries (MNEHTECH) (Columns 1 and 2 in Table 9). Even though the independent variable is significant for both 1 and 2 years lags, the effect becomes larger as the structure of the lags increases, a property that is supported by the higher value of the MNEMTECH coefficient at $t-2$. On the other hand, we have not found learning effects for MNE firms operating in medium and low tech sector (Columns 3, 4, 5 and 6 in Table 9). This result implies that the MNE firms from high tech industries have a higher propensity to learn abroad and that this effect will be stronger as the MNE becomes more consolidated in foreign locations. The rest of the variables, i.e. Rd and size, behave as expected, being both positive and significant.

When considering patent applications both in Spain and abroad, we observe that the MNE status effect extends to both high and medium tech industries (Columns 7 to 10 in Table 9), while low tech industries remain unaffected (Columns 11 and 12 in Table 9). The same type of dynamic cumulative conclusion applies to the Pat_{it} setting, with the MNE effect becoming larger as the structure of the lags increases. Thus, the defensive mechanism implemented by the MNEs performing FDI prevails both in the high and medium tech industries and increases in intensity through time, particularly so in the former ones. Also in this case, Rd and size are both positive and significant.

Taking product innovations as the dependent variable (Columns 13, 14 and 15 in Table 9), we observe that only the MNEs integrated in medium tech industries learn abroad and that this learning process could be materialized in an ex-post increase of product innovations. We have not found any significant results for MNEs in high and low tech industries (Columns 13 and 15 in Table 9). A potential explanation for this latter observation relates to the capacity of high and low tech firms to introduce product innovations. High tech MNEs increase their patenting activity in Spain relative to local firms but do not introduce new products into the market, implying that patents are mainly process-oriented. The increment in productivity associated to the lagged MNE status of firms—described in

Table 8—counterparts this explanation, with high tech firms patenting abroad to protect their intellectual property and at home because of the knowledge acquired. This knowledge allows them to increase their productivity but does not lead to the introduction of new products.

At the same time, note that all the dependent variables considered illustrate the difficulties faced by the MNEs integrated in low tech industries to learn abroad. This finding can be justified by the fact that MNEs in this type of sectors show in general lower levels of R&D intensity, which could reflect their minor capacity for the absorption of knowledge abroad. As a result, the capacity of these firms to introduce new products in the market remains limited. Thus, their incentives to move abroad would differ from a direct acquisition of knowledge that could be used to increase their number of patents or to generate product innovations.

All in all, the results derived from these robustness tests allow us to affirm that the learning by FDI effects depend on the technological content of the industry where the MNE is integrated, being the impact higher in MNEs from high and medium tech industries.

5.6 Robustness test: learning effects by *host country income*

In this section, we perform a second set of robustness tests by differentiating the countries in which the FDI takes place according to their relative level of development/income. We replicate the previous analysis regarding the learning effects derived from the MNE status of firms on innovative outputs, productivity and by technological sectors while taking into account whether the FDI is located in either a high/medium income country (MNEHOSTHM) or a low-income one (MNEHOSTL).

Table 10 describes the learning effects on innovative outputs when accounting for the income differences existing across host countries. Defining the patent variables Pt_{it} and Pat_{it} as the dependent ones, the estimations show that the learning effects are significant when the destination of the FDI is a high/medium income country (Columns 1, 2, 5 and 6 in Table 10). These effects vanish when low-income FDI destinations are considered (Columns 3, 4, 7 and 8 in Table 10). The corresponding control variables, i.e. Rd and size, behave as expected, being both positive and significant.

When product innovation is taken as the dependent variable, the learning effects derived from the MNE status of firms become significant after a 2-year lag but only in high and medium income host countries (Columns 9 to 12 in Table 10). This result reinforces the evidence presented in Table 7, with the effects of learning on product innovation taking longer to materialize than for patent applications though only when considering high and medium income host countries.

Similarly, when replicating the analysis on productivity our results show that learning effects appear after a 2-year lag but only in high and medium income host countries (Columns 1 and 2 in Table 11). There is not any learning evidence when low-income hosts are considered (Columns 3 and 4 in Table 11). These results ratify those described in Table 8, where a reasonable period of time is required for learning to affect productivity. In the current setting, we observe that these learning effects are more likely to occur when the destination of the FDI are high and medium income countries. Moreover, the different signs of the size variable in both scenarios should also be emphasized. Note that smaller MNEs exhibit a larger productivity increase when locating in high/medium income countries, while larger firms are the ones that tend to exhibit a larger increase in productivity when considering the whole sample in Table 8.

Finally, we provide a description of the learning behavior of MNEs that can be observed when considering the Pat_{it} variable while taking into account the differences across both technological sectors and the income level of host countries. Table 12 shows that high and medium income hosts affect learning by FDI positively in high and medium tech industries, i.e. the Host HM variable is positive in all the estimations except for $MNEHTECH_{t-1}$ (Columns 1 to 4 in Table 12), while low tech industries remain unaffected (Columns 5 and 6 in Table 12).

At the same time, low-income host countries (Host L) display a positive effect on FDI learning only when considering two-period lagged medium tech industries (Column 10 in Table 12). Note also that, in the low-income case, MNEs in high tech industries require some time to adapt to the host economy before they start patenting (Colum 7 in Table 12). It should finally be emphasized that the learning effects described in Table 12 vanish when considering the variable Pt_{it}, requiring a more detailed analysis such as the one performed in the previous sections to be identified.

Overall, these results illustrate that the learning effects exhibited by MNEs are also determined by the relative level of development/income of the host country where the FDI takes place, which becomes particularly relevant when high and medium tech industries are considered.

6 Discussion of results and managerial implications

The vast majority of MNE studies have been focused on the effects that MNEs have in the host locations. However, evidence regarding the *domestic* advantages that the MNE status confers to firms in terms of technological or productivity performance is scarcer. We have aimed at covering this gap in the literature by providing new evidence of the firms' learning effects by FDI on innovative outputs and productivity levels.

Our findings confirm that the MNE status boosts the firms' innovative capacity because it provides access to new and important channels of technology and knowledge abroad, defining what we refer to as the learning by FDI process. Accordingly, the MNE status of firms generates ex-post positive benefits on innovative outputs, especially in terms of patent applications—both in Spain and the host locations—and product innovations. The MNE status of firms affects also the ex-post levels of productivity, although these effects are not immediately manifested but dilated through time. Additionally, learning effects have been shown to differ across industries and host locations for both measures of technological output. These effects are positive in industries with high and medium technological contents but not significant in low tech industries. Similarly, learning effects are also determined by the relative level of development/income of the country where the FDI takes place, being only significant when the host is a high/medium income country.

Thus, our main contribution to the literature is the introduction of the causal direction that goes from internationalization to innovation and productivity. Our results differ from those of the studies that analyze learning by exporting effects on innovative output and productivity in two main respects. First, learning by exporting studies argue that Spanish firms from laggard industries are more able to learn abroad than firms of medium and high tech content (Salomon and Jin 2007). However, our results show that learning by FDI effects are only evident among firms integrated in high and medium tech industries. Second, the connection suggested between learning by exporting and productivity has not yet provided conclusive results. In this regard, our findings reveal that the learning effects

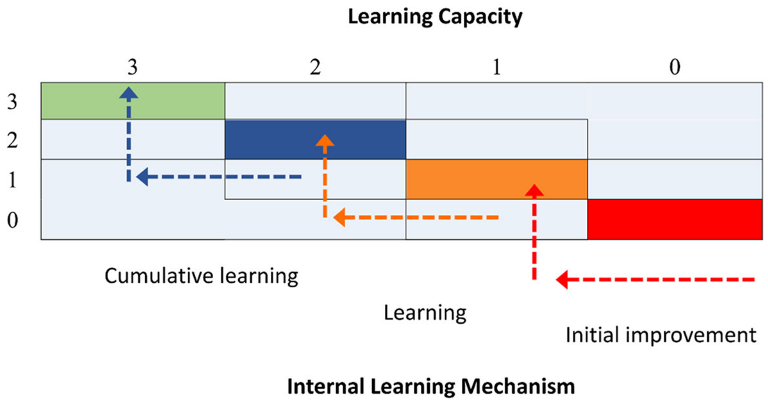

Fig. 6 Standard technological race scenario

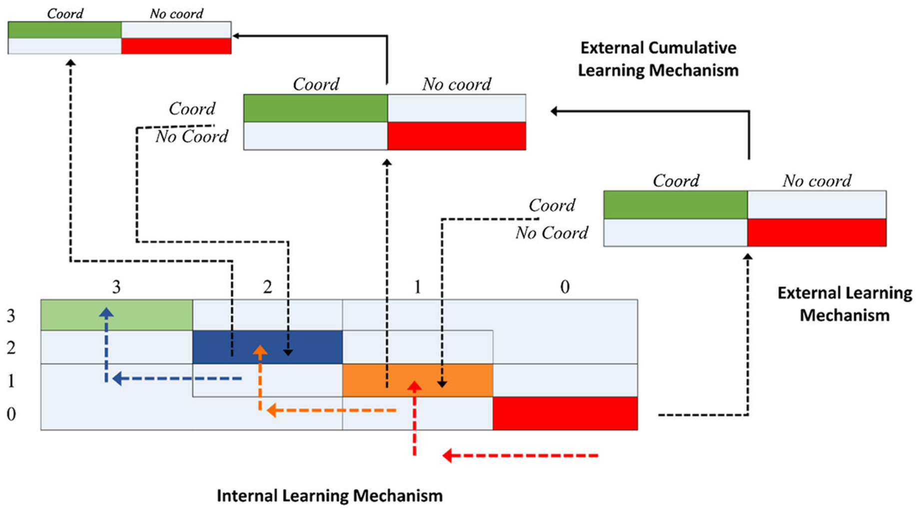

Fig. 7 Interactions between internal and external cumulative learning

derived from FDI could be manifested in a productivity increase after a reasonable period of time is allowed for them to materialize.

The results presented should incentivize the promotion of foreign investment by governments, given the ex-post positive effects for the competitiveness of domestic firms. Moreover, managers should be aware of the positive effects on the innovative performance of the firm that can be derived from its international expansion despite the higher resources required.

Finally, our analysis identifies the main characteristics of learning by FDI based on knowledge seeking motives and adds several insights to the relationship between internationalization, innovation and productivity. This opens new paths of research applicable to both the IB and international economics literatures. That is, the capacity of firms to improve their productivity through internationalization and compete locally afterwards introduces a new potential strategy in the competitive scenario considered by the literature on international economics, where productivity improvements at the local level are the ones leading to the internationalization of firms.

In this regard, the results obtained add a new dimension to the industrial organization literature on technological races. Figure 6 represents a standard race scenario where a firm must improve sequentially its learning capacity and accumulate further knowledge by shifting through different strategic environments, which can be assumed to account for different interactions with competitors. This cumulative mechanism is internal to the firm and even though firms can acquire knowledge abroad, they are assumed to do so only after having sufficiently improved their productive capacity at the local level.

The formal framework derived from our results introduces the possibility of learning through FDI using an external cumulative mechanism based on different strategic/coordination interactions with foreign firms. This mechanism adds a new dimension to technological races and their corresponding strategic settings, providing a direct link between the industrial organization literature and the IB one. Figure 7 summarizes the interactions taking place between the internal learning mechanism described in Fig. 6 and the external cumulative learning one that follows from our results.

At the same time, the sequential improvements derived from the learning process of firms add a dynamic perspective to the entry environments considered by the IB literature when analyzing the internationalization strategies of MNEs. It should be noted that the emergence of "internationalization partnerships" as a strategic policy developed at the local level but implemented at a global scale to share knowledge in a dynamic environment is gaining relevance in the IB literature (Choi and Yeniyurt 2015; Zheng et al. 2016).

One of the limitations of this research relates to the complexity of the learning process and the analysis of its associated effects. Even though we have introduced a lag structure in the model to capture the effects of the prior MNE status of firms on their ex-post innovative outputs, we cannot guarantee that this result is exclusively caused by learning abroad. That is, the vast majority of MNEs composing our sample were also exporters (only six were not exporters), which implies that our study considers implicitly the effects of learning by exporting.

Moreover, the dataset employed does not allow us to account for the entry strategies of MNEs in foreign locations. That is, identifying whether Spanish firms acquire or merge with a host company or entry through greenfield would allow us to account for the different knowledge acquisition alternatives defining any potential entry strategy in the foreign locations. At the same time, it seems plausible to assume that the intensity of the knowledge flows received is determined to a certain extent by the entry mode chosen by the MNEs.

In addition, our analysis has focused on a sample of Spanish manufacturing firms, which implies that we should be cautious about generalizing its results. Thus, it would be interesting to test the model proposed in this paper with samples from different countries. Other potential extension could consist of dividing the MNE status variable between the firms that were already MNEs and those that have opened new subsidiaries during the period considered. This differentiation would allow to capture the effects that changes in the status of firms have on their technological performance.

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Appendix: Learning by FDI analysis

See Tables 13, 14 and 15.

Table 13 Technological classification according to the ESEE data

High tech content
N9. Chemical and Chemical products
N15. Computing Machinery, Electrical machinery, Precision and optical instruments
Medium tech content
Medium high tech content
N16. Machinery, equipment and electrical machinery and apparatus, n.e.c
N17. Motor vehicles, trailers and Semi-trailers
N18. Other transport equipment
N14. Agricultural Machinery
Medium low technology content
N20. Other manufacturing industries
N10. Rubber and plastic product
N11. Other non- metallic mineral products
N12. Basic Metal
N13. Fabricated metal products
Low tech content
N1. Meat Industry
N2. Food and Tobacco
N3. Beverages
N4.Textiles
N5. Leather and footwear
N6. Wood
N7. Paper, paper products, publishing and printing
N19. Furniture

Classification based on ISIC Rev.3 Technology Intensity Definition (OCDE)

Table 14 Correlations matrix: MNE status and control variables

Correlation matrix			
MNE	1		
Rd	0.0108	1	
Size	0.3483	−0.1322	1

Table 15 Correlation matrix: lagged structure and dependent variables

	INNO	Pt	Pat	Pd
MNE_{t-1}	0.0393	0.1255	0.1255	0.2397
MNE_{t-2}	0.0404	0.1211	0.1211	0.235

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