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Absorptive capacity from foreign direct investment in Spanish manufacturing firms

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ABSTRACT

This paper deals with the determinants of absorptive capacity from foreign direct investment (FDI) spillovers. We study how firm behavior, capabilities, and structure drive absorptive capacity such as research and development (R&D) activities and expenditures, R&D results, internal organization of innovation, external relationships of innovation, human-capital quality, family management, business complexity, and market concentration. Our results enhance and complement previous evidence of the determinants of absorptive capacity, particularly with different approaches to innovative activities as mediators of the capability.

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1. Introduction

Spillovers within an industry are improvements in productivity that local firms learn from foreign companies operating in the same sector. Similarly, spillovers from foreign direct investment (FDI) arise from transactions outside specific markets, in which resources – and particularly knowledge – spread without any contractual relationship (Meyer, 2004). Spillovers in developing countries are widely studied; however, empirical evidence for developed countries is less common.

The capacity for absorption refers to a company's ability to apply knowledge from competitors via these spillovers (Cohen & Levinthal, 1989). This paper analyzes the capabilities to absorb spillovers from FDI, measured as technical progress in Spanish manufacturing firms. We focus on how firm behavior, capabilities, and structure drive this absorptive capacity of FDI. However, doing so requires asking why a company's resources and capabilities affect the absorptive capacity of FDI in the first place. The *approach of resources and capabilities* proposes that valuable, rare, imperfectly imitable, and imperfectly substitutable resources are necessary, making them a key source of competitive advantage (Barney, 1991).

This study furthers the understanding of the dynamic capabilities of a firm (Teece, Pisano, & Shuen, 1997), particularly regarding the factors that limit or enhance the ability to absorb and capitalize on knowledge spillover. Firm-specific idiosyncrasies, distinctive institutional and industrial environment drive foreign investments (Wang, Hong, Kafouros, & Boateng, 2012b), and with this in mind, we focus on absorptive capacity, which is a resource, a capability, and a good source of sustainable competitive advantage over time (Cohen & Levinthal, 1990).

In Spain, research evaluates the effect of FDI and R&D on technical progress at the industrial level (Rosell-Martínez & Sánchez-Sellero, 2012). Barrios, Dimelis, Louri, and Strobl (2004) also use the survey of business strategies (ESEE) to study the absorptive capacity of spillovers from FDI in Spanish manufacturing firms. Alvarez and Molero (2005) use ESEE to identify horizontal spillovers from FDI in Spanish manufacturing industries according to their high, medium, or low technological content. Similar to Barrios et al. (2004), Alvarez and Molero (2005), and Rodríguez and Pallas (2008), we use the ESEE in relation to FDI but extend its application to the factors determining the behavior, the capabilities and the structure of the firm which are driving absorptive capacity, such as research and development (R&D) activities, results of R&D, internal organization of innovation, external relationships of innovation, quality of human capital,

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family involvement, complexity of the business, and market concentration.

Our conclusions are relevant for managers and policy makers. In particular, if a firm knows what determines its capacity to absorb FDI spillovers, then firm managers can make better decisions regarding efficiency and performance improvement. Policy makers can also identify which industries will benefit most from FDI spillovers and adjust their fiscal incentives accordingly.

The paper is structured as follows. Section 2 looks at the capacity for absorbing FDI in the strict sense; Section 3 investigates the factors in the capacity to absorb FDI; Section 4 presents the models, data, and methodology for explaining the factors in the capacity to absorb FDI. The final section concludes.

2. Absorptive capacity and foreign direct investment

Some studies of FDI spillovers evaluate the absorptive capacity of local firms (Dimelis, 2005). The results of such absorption are very hard to copy, which makes the process of absorption a competitive advantage in and of itself (Peteraf, 1993). Accordingly, businesses make investments that increase their ability to absorb, and the more externalities that are in their environments, the greater the incentive to invest in improving the capacity for absorption (Cohen & Levinthal, 1990).

Absorptive capability is a process involving four diverse and complementary stages or dimensions: acquisition, assimilation, transformation, and exploitation (Zahra & George, 2002). It requires a business to evaluate, assimilate, and apply knowledge transmitted from another (Lane & Lubatkin, 1998). The academic literature widely covers the capacity to absorb from FDI and defines absorptive capability as the ability to identify, assimilate, and apply knowledge from external sources (Cohen & Levinthal, 1990) for commercial purposes.

In particular, companies can absorb foreign technology through competitive rivalry, worker mobility, or the demonstration effect (Mody, 1989). FDI increases competition, allowing local businesses to absorb technological novelties and effective processes from foreign firms, thus raises their productivity (Rugman & Verbeke, 2003).

Taking advantage of the spillovers from FDI, however, again depends on the capacity to absorb them (Cohen & Levinthal, 1990). A capacity to absorb (Rugman & Verbeke, 2001) largely depends on technological abilities (Ben Hamida, 2006; Narula & Marin, 2003) but varies with the sectors in which receptor firms operate. This is why companies in certain sectors, depending upon the degree of concentration in the sector, are more susceptible to developing abilities, a flow of knowledge, technological advances and, consequently, the capacity for absorption (Deeds, De Carolis, & Coombs, 2000).

Previously, Barrios and Strobl (2002) find that in Spain only domestic firms with the appropriate "absorptive capacity" can apply the positive externalities often associated with FDI. Wang, Deng, Kafouros, and Chen (2012a) find that the pace of foreign entry and the irregularity of foreign entry have a moderate effect on the relationship between the level of foreign presence and the productivity of host-country firms. Also, they analyze how the intensity of R&D affects the pace of foreign entry and the irregularity of foreign entry. We contribute to the literature by studying the determinants of the behavior, firm capabilities, and firm structure that affect absorptive capacity of spillovers from FDI.

3. Factors determining absorptive capacity from foreign direct investment

Lane and Lubatkin (1998) and Van den Bosch, Volberda, and de Boer (1999) are some of the first to study the factors determining absorptive capacity. Barrios et al. (2004) and Wang et al. (2012a) also analyze how well firms absorb technical advances arising out of spillovers from a foreign presence in their sector. We add to this by including the moderating effect of a number of determinants of spillover absorption.

3.1. R&D activities and expenditures

3.1.1. R&D activities

The intensity of R&D, total intangible assets per worker, and technological gaps determine how well local firms absorb FDI spillover (Liu, Siler, Wang, & Wei, 2000; Dimelis, 2005). Innovation, therefore, can improve absorptive capacity (Veugelers, 1997). However, businesses do not tend to undertake R&D activities if they can simply glean technological knowledge from outside sources (Nieto & Quevedo, 2005).

In this way, a capacity for absorption is relevant in acquiring new technology that spills over from FDI, and it therefore affects the productivity of local firms (Caves, 1974). The effects may include creating, diffusing, and commercializing technological innovations (Gugler & Dunning, 1994). The absorptive capacity of an enterprise, however, comes through acquiring, assimilating, and propagating new knowledge gleaned from outside the firm; more overall R&D in an industry enhances it (Liao, Welsch, & Stoica, 2003).

In sum, R&D activities prompt technological change, expand new knowledge, and improve how people assimilate such knowledge. All of this improves a firm's absorptive capacity (Cohen & Levinthal, 1990). Consequently, our hypothesis is

Hypothesis 1. R&D activity increases a firm's ability to absorb spillovers.

3.1.2. R&D expenditures

Because R&D spending may create competitive advantages, it encourages companies to absorb technological spillovers from external sources (Veugelers, 1997). In turn, R&D expenditures imply that companies are willing to assimilate routines and processes, thereby increasing their stock of knowledge and improving their capacity for absorption (Mowery, Oxley, & Silverman, 1996), which improves and sustains overall company performance (Todorova & Durisin, 2007). In a country-level analysis of host countries, R&D expenditures favor the absorption of technological knowledge from FDI (Bodman & Le, 2013). Overall then, we expect R&D expenditures to increase absorptive capacity of spillovers from FDI at the firm level. Accordingly, whereas Hypothesis 1 proposes that R&D activities favor absorption, Hypothesis 2 proposes that R&D intensity increases absorption.

Hypothesis 2. A local company's R&D costs divided by its stock of capital has a positive relation to a company's capacity to absorb spillovers

3.2. R&D results: Patents, product innovations, and process innovations

Beyond the development of R&D activities (Hypothesis 1) and R&D intensity (Hypothesis 2), we test whether R&D results (patents, product innovations, and process innovations) increase absorptive capacity. One type of R&D result in particular, patents, is a determinant of absorptive capacity (Coombs & Bierly, 2006)—particularly technology licenses (Atuahene-Gima, 1992). In this sense, the number and importance of patents signals absorptive capacity (Baum, Calabrese, & Silverman, 2000; Zucker, Darby, & Armstrong, 2002).

However, the existence of patents in an enterprise may be common practice in its sector, which makes appropriating innovations more difficult and favors protecting innovation within an industry (Cohen & Levinthal, 1990). Thus, patents should mitigate spillovers and the absorption of knowledge associated with those patents. Furthermore, when a local firm owns a patent, it is exploiting a competitive advantage and likely has no interest in using innovations or improvements from other companies.

Local companies can imitate innovative foreign firms (Meyer, 2003), and their capacity for technological absorption can be measured through their innovations in products and processes (Narula & Marin, 2003; Ben Hamida, 2007). Furthermore, the capacity to absorb innovation improves when there is a greater quantity and quality of outside technological knowledge (Cohen & Levinthal, 1990). The process of developing new products also improves absorptive capacity, and this capacity improves efficiency and productivity (Atuahene-Gima, 1992; Stock, Greis, & Fischer, 2001).

Ben Hamida and Gugler (2009) show that using foreign knowledge efficiently requires mid-level technological capability. They measure technological capability through product and process innovation for Swiss manufacturing and services/construction local firms.

We test whether a firm that obtains R&D results can apply and produce knowledge (patents, product innovations, and process innovations). This is the absorptive capacity of external knowledge. On the basis of all these arguments and to capture the differing behaviors of patents, product innovations, and process innovations, we propose the following two hypotheses:

Hypothesis 3. There is a significant relationship between the number of patents a local firm owns and its ability to absorb spillovers.

Hypothesis 4. The number of product and process innovations in a local business improves its ability to absorb spillovers.

3.3. Internal organization of innovation

We expect the transfer of information among departments (i.e., effective internal communication of information that companies assimilate and use) to increase the capacity for absorption (Van den Bosch et al., 1999). To maximize this communication, the firm must design flexible formal and informal organizational structures (Liao et al., 2003), it must create multidisciplinary teams and close links between the R&D department and other departments (Gupta & Govindarajan, 2000; Meeus, Oerlemans, & Hage, 2001), and it must encourage innovation (Jones & Craven, 2001).

A culture of innovation stimulates knowledge, improves execution, has effective problem resolution, and encourages suggestions and continuous learning, because these things increase the capacity for absorption (Davenport, De Long, & Beers, 1998, Lenox & King, 2004). Also, the formal existence of an R&D department in a firm increases its absorptive capacity (Veugelers, 1997; Cassiman & Veugelers, 2002). Together, these things create sustainable competitive advantages (Lane, Salk, & Lyles, 2001; Tsai, 2001). Our hypothesis, therefore, is as follows:

Hypothesis 5. The number of actions a firm takes in relation to internal organization of innovation has a positive relation with its ability to absorb spillovers.

3.4. The external relationships of innovation

3.4.1. R&D activities: Internalization and externalization

Companies with strong, structured, internal R&D activities glean results from external sources more easily (Cohen & Levinthal, 1990; Veugelers, 1997; Lowe & Taylor, 1998). External R&D activities also increase absorptive capacity, but only if an organization already has absorptive capacity (Griffith, Redding, & Reenen, 2004).

Contrary to frequent conjectures, import-embodied R&D does not seem to improve the technological base of the host economies (Bodman & Le, 2013). There is some evidence that externalized R&D activities strengthen the capacity to absorb spillovers from foreign companies (Veugelers, 1997; Lowe & Taylor, 1998). However, our hypothesis is that outsourcing R&D obtains only minor product and process innovations. Thus, firms are more likely to outsource R&D when they are less efficient in R&D than supplier companies are. Whereas the supplier of R&D get economies doing R&D, has not specific assets for R&D development and their R&D is relatively standardized. Accordingly, we include in our model other variables related to R&D intensity and R&D results. We expect a negative coefficient between outsourcing R&D activities and absorptive capacity of spillovers from FDI.

Hypothesis 6. Outsourcing R&D activities has a negative effect on absorptive capacity from FDI.

3.4.2. External collaboration for innovation

Cooperation with universities, research and technology centers, engineering and consultancy business, suppliers, clients, and competitors may enhance a firm's capacity for absorption. In turn, subsidiaries of multinational enterprises transfer local technology and information by cooperating with local firms (Park, 2012). The absorptive capacity of the knowledge transferred has intensified over the last few years in cooperative networks for innovation (Tether, 2002).

Park and Ghauri (2011) maintain that collaborative support from knowledge transferors is a prerequisite to help organizations to absorb technological capabilities, and Miozzo and Grimshaw (2008) show that absorptive capacity improves the transfer of knowledge about information technology. We consider effects of relationships with clients, universities, technology centers, suppliers, competitors, joint ventures, and other innovative entities on the absorptive capacity of spillovers from FDI in manufacturing firms.

In addition, the closer the relationship among firms, the greater the absorptive capacity of tacit knowledge (Dyer & Nobeoka, 2000). Not all firm relationships improve absorptive capacity, however. In fact, interorganizational agreements for acquiring external technology might reduce absorptive capacity (Lei & Hitt, 1995). In short, our hypothesis is as follows:

Hypothesis 7. The number of actions a local business takes in relation to external collaboration for innovation has a positive effect on the firm's ability to absorb spillovers.

3.4.3. Relationships with the state in innovation

Financial resources affect the capacity to absorb, because they provide the means for carrying out R&D activities, for reaching cooperation agreements with other firms and institutions, and for employing suitably trained staff, among other things (Ghoshal & Bartlett, 1988; Kamien & Zang, 2000). Publicly funded R&D produces different results, however (David, Hall, & Toole, 2000). Some studies find positive effects from publicly funding R&D (Aerts & Schmidt, 2008) and others find insignificant or negative effects (Lach, 2002).

The advantages of public funding for R&D include more funding and better organizational capabilities (Buisseret, Cameron, & Georgiou, 1995; Trajtenberg, 2001). However, publicly funding R&D is less effective than privately funding it (Griliches, 1986). An interpretation of second order about the sign of this relationship is related to the design of the public-funding program in the analyzed geographic area. A negative relationship between public funding and absorptive capacity suggests the existence of an adverse selection problem. That is, public funding programs fail to support the most valuable R&D projects. In addition, public funding provides financial resources to R&D projects that are not able to get private funding. Hence, the hypothesis is as follows:

Hypothesis 8. There is a significant relationship between the percentage of public funding in R&D expenditures in local firms and the ability of those firms to absorb spillovers.

National governments may attempt to attract FDI, principally because they hope it will lead to positive spillovers for local businesses (Narula & Dunning, 2000). Further, these governments may adopt measures that favor innovation in local firms so that they will be in a position to absorb knowledge from foreign enterprises. Some of these decisions may include stimulating the entry of FDI, reducing obstacles to FDI, supporting investments, offering tax incentives, adjusting patent regulation, and so forth (Dunning & Gugler, 2008; Oxelheim & Ghauri, 2003).

Public policies aimed at attracting FDI should be directed toward supporting private enterprises, but also universities, research centers, and industrial associations (Padilla-Pérez, 2008). Accordingly, firms that collaborate with the public sector in innovation gain an advantage by developing absorptive capacity (Zucker et al., 2002; Fabrizio, 2009). Consequently, we propose the following hypothesis:

Hypothesis 9. The number of innovation links between local firms and the public sector has a positive effect on the ability of local firms to absorb spillovers.

3.5. Quality of human capital

Absorption occurs through the interaction and transfer of knowledge among skilled staff members (Criscuolo, 2005). Hence, personnel who have the abilities, training, and experience to absorb new knowledge are necessary (Nonaka & Takeuchi, 1995). Companies with specialists, qualified technicians, scientists, engineers, and staff with experience in specific areas in turn have more absorptive capacity (Gupta & Govindarajan, 2000; Zahra & George, 2002). Skilled workers from businesses entering the market through FDI may decide to work for local firms and thus may also transfer their knowledge from a foreign to a local enterprise (Kaufmann, 1997). Employees' absorptive capacity varies with the level of effort they put in (Kim, 1998), the enterprises' formalization of policies procedures, the level of coordination among members, and the existence of shared ideology (Van den Bosch et al., 1999).

As we can see, human capital directly affects the capacity for absorption. Learning processes in receptor companies (Cohen & Levinthal, 1990; Kim, 1998; Meeus et al., 2001) include improving workers' skills (as a factor of production), but also include the ability to learn from the foreign technological base (Bodman & Le, 2013). Accordingly, we hypothesize the following:

Hypothesis 10. There is a positive relation between the proportion of university graduates in a company's staff and the company's ability to absorb spillovers from FDI.

3.6. Family management of businesses

Family management affects firms' financial behavior (Schleifer & Vishny, 1997), as well as their productivity (Palia & Lichtenberg, 1999). In particular, the concentrated ownership structure encourages managers to control and reduce agency costs related to the separation of ownership and management (Schleifer & Vishny, 1997). Consequently, family firms have an advantage because their concentrated ownership structures allow close supervision of management (Berle & Means, 1932).

However, family management can also have negative effects on technical progress and absorptive capacity. Restricted investment in R&D and new technologies, for example, can be a result of family managers using resources to finance their own lifestyles (Chandler, 1990). Additionally, family managers may be excessively tolerant of inadequate performance of other family members (Pollack, 1985). The pool from which family managers come is very limited and much smaller than the pool of professional managers, after all, so their talents are less extensive and can jeopardize productivity (Burkart, Panunzi, & Shleifer, 2002). Similarly, excessive control can impede changes in management styles, staffing policies, or other matters, also limiting productivity (Gulbrandsen, 2005) and the acquisition of external knowledge.

On the basis of these statements, we propose the following hypothesis:

Hypothesis 11. Family management has a significant (positive or negative) influence on absorptive capacity.

3.7. Complexity of a business: Differentiated products and complex production process

The entry of FDI may encourage the most competitive local firms to develop proactive strategies that apply their full range of technological resources and capabilities and thus help them exploit technological knowledge, bring new products to market, and improve production processes (Zack, 1999). Technical and managerial competence is crucial to absorbing knowledge (Szulanski, 1996), and having differentiated products or complex production processes enhances that (Pittaway, Robertson, Munir, Denyer, & Neely, 2004; Kaminski, de Oliveira, & Lopes, 2008). In turn, we make the following hypothesis:

Hypothesis 12. The more differentiated a firm's products are and the more complex its production process are, the greater its ability to absorb spillovers.

3.8. Market concentration

In the literature, industry concentration creates ambiguous results. On one hand, it encourages collusion, which undermines technological progress (Davies & Caves, 1987). On the other hand, firms in concentrated industries are in a better position to fix monopoly prices, which increases the added value per employee (Kokko, 1994).

Furthermore, market competition discourages relationships between foreign firms and local actors due to the risks of unintended knowledge spillovers to rivals (Santangelo, 2012). This suggests that firms can use relationships with competitors to improve their absorptive capacity from FDI.

In addition, the literature analyzes market concentration in relation to the productive efficiency of industry. The outcome is that economies of scale improve specialization, market power, production efficiency (Blomström, 1986). Accordingly, the hypothesis is as follows:

Hypothesis 13. There is a positive relation between market concentration and absorptive capacity.

4. Model, data, and methodology

4.1. Data

We analyze homogenous information at the individual business level for 20 manufacturing sectors over 13 years, from 1994 to 2006. The information is from the survey of business strategies

Table 1
Sample firms by sector and size.

Sectors	Fewer than 200 employees (%)	More than 200 employees (%)	Total (%)
Meat industry	1.71	0.83	2.54
Food products and tobacco	6.01	2.89	8.90
Drinks	1.42	0.88	2.30
Textiles and clothes	6.84	1.18	8.02
Leather and footwear	2.65	0.00	2.65
Timber industry	3.30	0.71	4.01
Paper industry	2.00	1.12	3.13
Editing and graphic design	4.13	1.12	5.25
Chemical products	3.24	3.36	6.60
Rubber and plastic products	3.42	1.53	4.95
Nonmetallic mineral products	5.25	2.48	7.72
Iron and noniron metals	1.65	1.59	3.24
Metal products	10.38	2.30	12.68
Industrial and farm machinery	4.95	1.89	6.84
Office machinery, data process, etc.	1.24	0.41	1.65
Machinery and electrical material	3.18	2.30	5.48
Motor vehicles	1.83	3.24	5.07
Other transport material	1.42	0.71	2.12
Furniture industry	4.42	0.71	5.13
Other manufacturing industries	1.53	0.18	1.71
Total	70.6	29.4	100.0

Source: Survey of business strategies and own elaboration.

from the Spanish Finance Minister. This is a voluntary survey, but the participation rate is high (around 91%). The sample-selection criterion is the stratified random sampling by sector and size from a representative sample of firm population, as we can see in Table 1. Data on prices come from the IPRI industrial prices index calculated by INE, the Spanish national statistics institute.

4.2. Model and methodology

The model is a production function that contains the effects of foreign capital and foreign presence on added value (output). It includes variables that arise from the interaction of a foreign presence in a sector with other variables. These combined variables permit an analysis of the factors determining absorptive capacity from FDI.

$$\begin{aligned}\mathrm{Ln}(\mathrm{VA}_{i,t}) = {} & \alpha + \beta_0 ln(VA_{i,t-1}) + \beta_1 ln(CLAB_{i,t}) + \beta_2 ln(CAP_{i,t}) \\ & + \beta_3 ln(NLAB_{i,t}) + \beta_4 PAR_{i,t} + \beta_5 PRE_{i,t} + \beta_6 RDA_{i,t} \\ & + \beta_7 RDC_{i,t} + \beta_8 NPAT_{i,t} + \beta_9 INPRD_{i,t} + \beta_{10} INPRC_{i,t} \\ & + \beta_{11} INTORG_{i,t} + \beta_{12} ERDA_{i,t} + \beta_{13} EXTCOL_{i,t} \\ & + \beta_{14} PUBFND_{i,t} + \beta_{15} RPUB_{i,t} + \beta_{16} SLAB_{i,t} + \beta_{17} FAMI_{i,t} \\ & + \beta_{18} DIFP_{i,t} + \beta_{19} PROC_{i,t} + \beta_{20} CDOM_{i,t} + \beta_{21} EXP_{i,t} \\ & + \beta_{22} RDA \times PRE_{i,t} + \beta_{23} RDC \times PRE_{i,t} + \beta_{24} NPAT\end{aligned}$$

The Spanish finance ministry sent a questionnaire to 1860 firms of 20 different manufacturing sectors by A 91% response rate suggests that 1696 firms responded. We delete missing values and outliers in which the ratio of added value to capital stock is more than three times the sample median or less than a third of the sample median. We also delete outliers in which the ratio of added value to labor productivity is higher than three times the sample median or less than a third of the sample median. The final model includes 1288 observations of 327 businesses in 20 different manufacturing sectors. The reduction in the number of firms is mainly due to the high number of variables in the model. So, some firms do not complete the questionnaire in some of the variables. This causes these firms not to be included in the estimation.

Expression (1) allows for the persistence of added value by specifying the dynamic production function, including its delayed values as a regressor. Estimation of this panel data is carried out via the generalized method of moments (GMM) proposed by Arellano and Bond (1991), which provides a consistent estimate in the presence of heteroskedasticity of unknown form. This model links to the theoretical contributions and empirical evidence from Blundell, Griffith, and van Reenen (1999), Aghion, Bloom, Blundell, Griffith, and Howitt (2005), and Girma, Gong, and Görg (2009).

Tables 2 and 3 give the descriptive statistics (mean, standard deviation, minimum, and maximum) and correlation matrix for the independent and dependent variables of Expression (1) to facilitate the interpretation of the regression results.

The following are details for the variables in the model of the production function in absorptive capacity from FDI.

α is the natural logarithm of technological level.

VA is output measured as value added at constant prices. Value added at constant prices is the value added at current prices divided by the IPRI. Value added at current prices is the sum of sales, variation in stocks for sale, other current management income, and variation in stocks bought, less purchases and external services.

CLAB is the cost of the input labor, which equals the cost of labor at constant prices per employee. Labor costs at constant prices equal labor costs at current prices divided by the IPRI.

CAP is the servicing of capital input, defined as the stock of capital at constant prices, which equals the stock of capital at current prices divided by the deflator for gross formation of fixed capital (from the INE's Spanish national accounting figures). The stock of capital at current prices equals tangible fixed assets at current prices.

NLAB is the servicing of labor input, expressed as number of workers employed.

PAR is a control variable that equals the percentage of foreign shareholders (direct or indirect) in the firm.

PRE is the foreign presence in the sector, measured as total sales by foreign firms in sector *s* in year *t*, divided by the sales of all companies, local or foreign, in the same sector and year, expressed as a percentage. A firm is foreign when foreigners hold more than 10% of its capital; this is based on criterion in the Fifth Manual of the International Monetary Fund.

Table 2
Descriptive statistics.

Variables	Mean	SD	Min.	Max.	Variables	Mean	SD	Min.	Max.
$(\ln(VA))_t$	15.6663	1.4487	12.069	19.838	$(INTORG)_t$	1.4371	1.4873	0	4
$(\ln(CLAB))_t$	10.2569	0.2606	9.353	11.433	$(ERDA)_t$	0.4115	0.4923	0	1
$(\ln(CAP))_t$	15.6291	1.5524	11.826	20.106	$(EXTCOL)_t$	1.8362	1.9135	0	8
$(\ln(NLAB))_t$	4.9261	1.3668	1.792	8.979	$(PUBFND)_t$	0.0002	0.0021	0	0.06
$(PAR)_t$	30.4992	44.4693	0	100	$(RPUB)_t$	0.1949	0.4615	0	2
$(PRE)_t$	0.5414	0.2563	0	0.964	$(SLAB)_t$	7.1797	9.1274	0	74.5
$(RDA)_t$	0.6079	0.4884	0	1	$(FAMI)_t$	0.3051	0.4606	0	1
$(RDC)_t$	0.0362	0.0739	$1.7e^{-10}$	0.735	$(DIFP)_t$	0.5023	0.5002	0	1
$(NPAT)_t$	1.4984	10.9665	0	190	$(PROC)_t$	2.1654	1.4802	0	5
$(INPRD)_t$	0.8727	1.3648	0	4	$(CDOM)_t$	35.2011	35.293	0	100
$(INPRC)_t$	0.6514	0.8043	0	2	$(EXP)_t$	0.2799	0.2834	0	1

Table 3
Correlation matrix.

Variables	$(\ln(VA))_{t-1}$	$(\ln(CLAB))_t$	$(\ln(CAP))_t$	$(\ln(NLAB))_t$	$(PAR)_t$	$(PRE)_t$	$(RDA)_t$	$(RDC)_t$	$(NPAT)_t$	$(INPRD)_t$	$(INPRC)_t$
$(\ln(VA))_{t-1}$	1.000										
$(\ln(CLAB))_t$	0.424	1.000									
$(\ln(CAP))_t$	0.972	0.401	1.0000								
$(\ln(NLAB))_t$	0.982	0.347	0.962	1.000							
$(PAR)_t$	0.367	0.270	0.376	0.353	1.000						
$(PRE)_t$	0.095	0.174	0.084	0.081	0.267	1.000					
$(RDA)_t$	0.462	0.203	0.441	0.463	0.202	0.199	1.000				
$(RDC)_t$	0.242	0.252	0.193	0.223	0.011	0.158	0.379	1.000			
$(NPAT)_t$	0.159	0.113	0.155	0.153	−0.044	0.013	0.096	0.236	1.000		
$(INPRD)_t$	0.201	0.107	0.184	0.197	0.005	0.119	0.401	0.205	0.075	1.000	
$(INPRC)_t$	0.169	0.042	0.196	0.178	0.064	0.115	0.282	0.095	0.034	0.315	1.000
$(INTORG)_t$	0.442	0.217	0.432	0.440	0.137	0.113	0.620	0.382	0.145	0.430	0.314
$(ERDA)_t$	0.415	0.174	0.410	0.417	0.168	0.158	0.672	0.405	0.132	0.318	0.242
$(EXTCOL)_t$	0.530	0.277	0.517	0.534	0.231	0.228	0.632	0.436	0.169	0.378	0.351
$(PUBFND)_t$	−0.030	−0.056	−0.021	−0.024	−0.025	−0.009	0.064	−0.009	−0.005	−0.010	0.006
$(RPUB)_t$	0.300	0.159	0.308	0.314	0.118	0.086	0.333	0.345	0.110	0.221	0.199
$(SLAB)_t$	0.255	0.401	0.227	0.201	0.107	0.030	0.211	0.404	0.198	0.070	0.005
$(FAMI)_t$	−0.095	−0.122	−0.086	−0.087	−0.372	−0.168	−0.001	0.019	0.084	0.020	−0.020
$(DIFP)_t$	−0.106	−0.006	−0.098	−0.081	0.007	0.088	−0.094	−0.076	−0.091	−0.122	0.037
$(PROC)_t$	0.390	0.149	0.376	0.402	0.120	0.050	0.190	0.017	0.111	0.121	0.150
$(CDOM)_t$	0.223	0.093	0.219	0.221	0.168	0.151	0.188	0.027	−0.001	0.130	0.074
$(EXP)_t$	0.331	0.116	0.339	0.342	0.245	0.122	0.362	0.008	0.047	0.172	0.179

Correlation matrix

Variables	$(INTORG)_t$	$(ERDA)_t$	$(EXTCOL)_t$	$(PUBFND)_t$	$(RPUB)_t$	$(SLAB)_t$	$(FAMI)_t$	$(DIFP)_t$	$(PROC)_t$	$(CDOM)_t$	$(EXP)_t$
$(INTORG)_t$	1.000										
$(ERDA)_t$	0.488	1.000									
$(PUBFND)_t$	0.051	0.070									
$(EXTCOL)_t$	0.654	0.594	1.000								
$(PUBFND)_t$	0.051	0.070	0.035	1.000							
$(RPUB)_t$	0.418	0.360	0.490	0.112	1.000						
$(SLAB)_t$	0.236	0.248	0.307	−0.019	0.249	1.000					
$(FAMI)_t$	0.025	0.019	−0.017	0.025	0.067	−0.028	1.000				
$(DIFP)_t$	−0.086	−0.031	0.024	0.003	0.036	−0.172	−0.122	1.000			
$(PROC)_t$	0.219	0.172	0.238	0.017	0.107	0.027	−0.002	0.074	1.000		
$(CDOM)_t$	0.182	0.085	0.161	−0.032	0.082	0.011	−0.075	−0.091	0.090	1.000	
$(EXP)_t$	0.325	0.272	0.359	0.017	0.210	0.110	−0.116	0.040	0.294	0.105	1.000

RDA (internal and external R&D activities) equals 1 if the company conducts R&D activities internally or externally; it equals 2 if the company conducts R&D activities both internally and externally. It equals zero otherwise.

RDC is the natural logarithm for R&D costs at constant prices divided by the stock of capital. R&D costs at constant prices equal R&D costs at current prices divided by the IPRI.

NPAT is the number of patents.

INPRD (product innovations) equals 1, 2, 3, or 4 to indicate how many of the following product innovations a firm achieves: (a) incorporation of new materials, (b) incorporation of new components or intermediate products, (c) incorporation of new designs and presentation, and (d) incorporation of new functions into the product. If the company made no innovations, the variable equals zero.

INPRC (process innovations) equals 1 or 2 to indicate how many of the following process innovations a firm achieves: (a) introduction of new machinery, or (b) new methods of organizing production. If neither happens, the variable equals zero.

INTORG (internal organization of innovation) equals 1, 2, 3, or 4 to indicate how many of the following mechanisms a firm puts in place: (a) a technology or R&D manager or committee, (b) a plan for innovation activities, (c) calculations to measure the results of innovation, or (d) evaluations of alternative technologies. If none of these are present, the variable equals zero.

ERDA (externally conducted R&D activities) equals 1 if R&D activities were carried out externally; otherwise, it equals zero.

EXTCOL (external collaboration for innovation) equals 1, 2, 3, 4, 5, 6, 7, or 8 to indicate how many of the following activities the business conducts: (a) collaborating with universities and/or technology centers, (b) collaborating technologically with clients, (c) collaborating technologically with suppliers, (d) collaborating technologically with competitors, (e) having technological cooperation agreements (joint ventures), (f) owning shares of businesses developing technological innovations, (g) employing recent college graduates, especially those with degrees in science, engineering, or technology, or (h) recruiting personnel with R&D experience in a business context. If the business conducts none of these activities, the variable equals zero.

PUBFND is the amount of public funding for R&D divided by total R&D costs.

RPUB (relationship with the public sector for innovation) equals 1 or 2 to indicate how many of the following activities a firm undertakes: (a) financing innovation with subsidized credit, or (b) participating in European Union (E.U.) research programs. If neither happen, the variable equals zero.

SLAB is the number of employees holding college degrees as a percentage of the staff.

FAMI (family control) equals 1 if a family group participates actively in the control or management of the enterprise; it equals zero otherwise.

DIFP (differentiated products) equals 1 if the firm's products are differentiated and zero if they are standard generics.

PROC (complex production process) equals 1, 2, 3, 4, or 5 to indicate how many of the following processes a company uses in production: (a) numerically controlled, computerized machine tools, (b) robotics, (c) computer-aided design (CAD), (d) a combination of any of those items via a computer-aided manufacturing, flexible manufacturing systems, or other central computer, or (e) local-area networking (LAN) in manufacturing activities. If the company uses none of the listed techniques, the value is zero.

CDOM is concentration in the principal (domestic) market, measured as the market share of the leading four firms in that market.

EXP is the exports divided by sales.

$\sum \beta_S \times SECT_{i,t,s}$ In this summation, $\mathrm{SECT}_{i,t,s}$ equals 1 if firm i in year t belonged to sector s. In any other case, it equals zero. The coefficient β_S represents the effect associated with sector s.

$\varepsilon_{\mathbf{i,t}}$ is the error term. Errors are taken to be independent and identically distributed.

Multiplying certain variables by *foreign presence* (PRE) isolates the moderation effect of those variables on the absorption of FDI spillovers. This construct of the model identifies:

- The effect of FDI in the sector on the firm's technical progress.
- The effect of foreign ownership on its technical progress.
- The effect of every determinant on the firm's technical progress.
- The effect of every determinant on the firm's capacity to absorb spillovers.

The degree to which domestic receptors themselves are multinationalized affects their absorptive capacity. For this reason, we include two control variables of technical progress: *export* and *absorptive capacity of export* (*export* multiplied by *foreign presence*). *Labor cost* acts as a control variable in the same production function because variation in the relative costs of inputs affects the relative demand for production inputs (labor and capital). This of course affects absorptive capacity. Thus, we introduce sector variables as a control variable of technical progress.

5. Estimation and discussion

All the estimators are obtained with Stata 9.0 and are shown in Table 4. Their columns record the estimates of the production function in absorptive capacity from FDI.

The Wald Test shows that significance is high. The residual behavior after the estimation is similar to white noise, and the Sargan test allows accepting the restrictions of overidentification so that the model has a good explanatory capacity.

The constant term and the delayed endogenous term are statistically equal to zero in the model (Table 4) explaining technical progress. As for the parameters of the production function, the elasticity of the output of labor and capital is consistent with the hypothesis of constant returns to scale. The estimation gives a coefficient for *capital* of 0.14 and a coefficient of 0.69 for *labor* (number of workers), together amounting to roughly 0.83. This is not statistically equal to 1 (the standard errors are very small, as this is a particularly efficient estimation), suggesting slightly decreasing returns to scale.

The coefficient of the control variable *labor costs* is positive and highly significant. This shows a positive link between the cost of

Table 4
Regression results.

Dependent variable: $(\ln(\mathrm{VA}))_t$	Coefficient	*p* Value	Dependent variable: $(\ln(\mathrm{VA}))_t$	Coefficient	*p* Value
$(\alpha)_t$	−0.0013	0.716			
$(\ln(\mathrm{VA}))_{t-1}$	0.0902	0.269	$(\ln(\mathrm{NLAB}))_t$	0.688	0.000***
$(\ln(\mathrm{CLAB}))_t$	0.4497	0.000***	$(\mathrm{PAR})_t$	0.0007	0.099*
$(\ln(\mathrm{CAP}))_t$	0.1445	0.000***	$(\mathrm{PRE})_t$	−0.0653	0.314
$(\mathrm{RDA})_t$	−0.0372	0.334	$(\mathrm{RDA})_t \times (\mathrm{PRE})_t$	0.1539	0.014**
$(\mathrm{RDC})_t$	−0.3098	0.327	$(\mathrm{RDC})_t \times (\mathrm{PRE})_t$	0.3968	0.339
$(\mathrm{NPAT})_t$	0.0001	0.910	$(\mathrm{NPAT})_t \times (\mathrm{PRE})_t$	−0.0002	0.815
$(\mathrm{INPRD})_t$	0.0083	0.400	$(\mathrm{INPRD})_t \times (\mathrm{PRE})_t$	−0.0123	0.379
$(\mathrm{INPRC})_t$	−0.0277	0.090*	$(\mathrm{INPRC})_t \times (\mathrm{PRE})_t$	0.0466	0.062*
$(\mathrm{INTORG})_t$	−0.0078	0.574	$(\mathrm{INTORG})_t \times (\mathrm{PRE})_t$	0.0044	0.828
$(\mathrm{ERDA})_t$	0.0538	0.194	$(\mathrm{ERDA})_t \times (\mathrm{PRE})_t$	−0.1213	0.048**
$(\mathrm{EXTCOL})_t$	0.0037	0.754	$(\mathrm{EXTCOL})_t \times (\mathrm{PRE})_t$	−0.0122	0.502
$(\mathrm{PUBFND})_t$	8.6462	0.060*	$(\mathrm{PUBFND})_t \times (\mathrm{PRE})_t$	−12.013	0.049*
$(\mathrm{RPUB})_t$	0.0339	0.281	$(\mathrm{RPUB})_t \times (\mathrm{PRE})_t$	−0.0721	0.141
$(\mathrm{SLAB})_t$	−0.0005	0.739	$(\mathrm{SLAB})_t \times (\mathrm{PRE})_t$	0.0016	0.515
$(\mathrm{FAMI})_t$	–	–	$(\mathrm{FAMI})_t \times (\mathrm{PRE})_t$	−0.1089	0.068*
$(\mathrm{DIFP})_t$	0.0076	0.786	$(\mathrm{DIFP})_t \times (\mathrm{PRE})_t$	0.0185	0.679
$(\mathrm{PROC})_t$	−0.0199	0.051*	$(\mathrm{PROC})_t \times (\mathrm{PRE})_t$	0.032	0.023**
$(\mathrm{CDOM})_t$	0.0003	0.534	$(\mathrm{CDOM})_t \times (\mathrm{PRE})_t$	−0.0003	0.596
$(\mathrm{EXP})_t$	0.0726	0.446	$(\mathrm{EXP})_t \times (\mathrm{PRE})_t$	−0.1059	0.203
Sector coefficients	Yes	–			
Wald test	983.97	–	First-order serial correlation	−4.20	0.0000
Sargan test (chi squared)	72.42	0.2464	Second-order serial correlation	1.46	0.1438

Notes: Figures with *, **, and *** indicate a level of significance of 10%, 5%, and 1%, respectively.

this input and output, with a value of 0.45. The control variable *percentage of foreign participation* thus has a positive influence on technical progress, as the estimated value of the coefficient is 0.0006528, being moderately significant. This implies that firms with more foreign capital make more technical progress than those whose capital is predominantly local. This is consistent with earlier studies, such as Rosell-Martínez and Sánchez-Sellero (2012), which find that FDI improves productivity in the manufacturing sector the year after the investment takes place.

The estimated coefficients for PAR act as a control variable and permit interpretation of PRE and the variables constructed via multiplication by PRE. This means that the presence of foreign participation makes it possible to identify and gauge a firm's absorptive capacity, as well as the elements determining this capacity. In the estimation, foreign presence in the sector (PRE) is statistically equal to zero. Hence, the variables multiplied by PRE explain the capacity to absorb technical advances from the spillovers of a foreign presence in the sector. We analyze these variables using as a reference the classification of the factors determining the capacity for absorption. Table 5 summarizes the hypothesis and the estimation results.

In the production function of absorptive capacity, we include the natural logarithm for R&D costs divided by the stock of capital (RDC) in a redundant manner in the estimation of output. This expenditure is included in the input capital, estimated as a stock (a proxy for the input capital). Because the coefficient for this variable can be zero, this type of capital's output is as elastic as the rest of the assets. The explanation likely lies in the way the survey measures R&D expenditures (it counts them when they are included as fixed assets). This accounting method occurs only if the innovation has been real, effective, and valuable.

Companies engaged in FDI in Spain site their technology centers outside that country. This suggests that an influx of foreign capital brings technological assets and that the variable R&D costs does not reflect what is spent outside Spain. In this way, the fact that the natural logarithm for R&D expenditures divided by the stock of capital (RDC) has no effect on technical progress implies that its adjusted cost is similar to that of other assets.

These arguments show that Hypothesis 2 cannot be accepted, because the result of the estimation shows that R&D expenditures have no effect on firms' absorptive capacity from FDI. This result is similar to previous studies of Spanish manufacturing firms (Rosell-Martínez & Sánchez-Sellero, 2012), which do not find a positive effect of R&D expenditures on technical progress.

Notably, internal and external R&D activities (RDA) also have no significant effect on technical progress. In contrast, the variable derived from multiplying internally or externally performed R&D activities (RDA) by *foreign presence in the sector* presents a coefficient of 0.15 on technical progress, which is highly significant. Hence, R&D activities do enhance the ability to absorb spillovers from a foreign presence in the sector, supporting Hypothesis 1.

The number of patents (NPAT) and of the variable arising from multiplying NPAT by foreign presence (PRE) can equal zero. In this way, there is no proof to confirm a relationship between patent ownership and absorptive capacity (Hypothesis 3). Despite this, they are in the model because patent ownership implies that local firms are exploiting this advantage, that it is difficult for others to appropriate it, that its privacy is enhanced, and that there is no interest in using third-party innovations or improvements.

Product innovations (INPRD) and the differentiation or generic nature of products (DIFP) also have no effect on technical progress, as did variables involving interaction of product differentiation (DIFP) with foreign presence in the sector (PRE) and of product innovations (INPRD) with foreign presence (PRE). These results imply that there is no proof to confirm Hypotheses 4 and 12, which propose that differentiated products, the number of product and process innovations, and the complexity of the production process improve absorptive capacity. The fact that absorptive capacity in local Spanish manufacturing enterprises is concentrated in items other than products may explain these findings. Thus, novel or different products have no relevance in determining absorptive capacity in Spanish manufacturing firms.

The coefficient for process innovations (INPRC) on technical progress is negative, with a value of −0.0277 and with moderate significance. This situation occurs because innovations in processes reduce the yields of a firm's productive factors, because there are fewer economies of scale. Consequently, process innovations are harmful to technical progress.

For its part, the interaction of process innovations (INPRC) with a foreign presence in the sector (PRE) produces a coefficient of 0.0466 on technical progress and is moderately significant. This is why process innovations, thanks to their positive effect on technological knowledge, favor the capability to absorb technical advances arising out of spillovers from foreign presences in the sector, confirming Hypothesis 4's predicted positive relationship between process innovation and absorptive capacity of spillovers from FDI. In addition to proving that R&D activity development (Hypothesis 1) and R&D intensity (Hypothesis 2) increase absorptive capacity, we test whether obtaining effective R&D results (patents, product innovation, and process innovations) do too. We confirm that if a firm obtains R&D results in process innovations, its capacity for apply and produce knowledge (process innovations) increases. So, this capacity shows up in the absorptive capacity of external knowledge from FDI.

Both the internal organization of innovation (INTORG) and the interaction of INTORG with a foreign presence (PRE) have no effect on technical progress. This is why it is not possible to confirm Hypothesis 5, which predicts a direct relationship between increased internal action on innovation and increased absorptive

Table 5
Hypothesis and estimation results of each factor effect on absorptive capacity from FDI.

Hypothesis. Factors determining absorptive capacity from FDI	Expected	Results
Hypothesis 1: R&D activities	Positive	Positive
Hypothesis 2: R&D expenditures	Positive	Not significant
Hypothesis 3: Patents	Exists	Not significant
Hypothesis 4: Product and process innovations	Positive	Positive
Hypothesis 5: Internal organization of innovation	Positive	Not significant
Hypothesis 6: Externalized R&D activities	Negative	Negative
Hypothesis 7: External collaboration for innovation	Positive	Not significant
Hypothesis 8: Public funding for R&D	Exists	Negative
Hypothesis 9: Relationships with the public sector in innovation	Positive	Not significant
Hypothesis 10: Quality of human capital	Positive	Not significant
Hypothesis 11: Family management of businesses	Exists	Negative
Hypothesis 12: Complexity of a business	Positive	Positive
Hypothesis 13: Market concentration	Positive	Not significant

capacity from FDI. One possible explanation is that Spanish manufacturing enterprises have many and varied forms of internal organization for innovation. This may make internal organization irrelevant to changes in absorptive capacity.

For its part, externally conducted R&D activities (ERDA) also have no effect. In contrast, the interaction of ERDA with a foreign presence in the sector (PRE) has a significant negative coefficient of −0.12 on technical progress. This negative coefficient support Hypothesis 6 concerning the negative effects of externalized R&D activities on absorptive capacity from FDI. The existing low absorptive capacity (Griffith et al., 2004) and high level of R&D import (Bodman & Le, 2013) of Spanish manufacturing firms may explain this.

It is worth pointing out that the results for Hypothesis 6 (externalized R&D activities have a negative effect on absorptive capacity) and for Hypothesis 1 (R&D activities increase absorptive capacity) suggest that internal R&D activities have a positive effect on absorptive capacity and that external R&D activities have a negative effect. This finding supports other evidence in the literature.

External collaboration for innovation (EXTCOL) and EXTCOL multiplied by foreign presence (PRE) have no effect on technical progress either. This estimation does not confirm Hypothesis 7 (increases in external collaboration increase absorptive capacity). This result occurs because when local businesses collaborate with outsiders for innovation, they are already exploiting the advantages that this gives and have no interest in making use of other advances from other companies.

Public funding for R&D (PUBFND) has a positive coefficient of 8.65 on technical progress, with a moderate significance of 0.06. This suggests that public funding for R&D favors technical progress. However, the coefficient for the variable multiplying public R&D funding (PUBFND) with the foreign presence in the sector (PRE) has a negative value of −12.01 with moderate significance of 0.05. For this reason, we accept Hypothesis 8, which predicts a negative relationship between public financing of R&D and absorptive capacity from FDI. Considering these results with the fact that public financing of R&D is less effective than private (Griliches, 1986), we can infer that businesses that privately fund R&D are in a better position to absorb spillovers from FDI in their sectors. In the hypothesis, we suggest that a negative coefficient indicates adverse selection in public funding. However, our results show a negative effect on absorptive capacity and a positive effect on productivity. In conclusion, we reject adverse selection.

Both the relationship with the public sector for innovation (RPUB) and the interaction of RPUB with foreign presence (PRE) are statistically equal to zero. Thus, we cannot confirm Hypothesis 9, which predicts a link between improvements in public sector innovation and absorptive capacity from FDI. This result may be due to the same motive behind external collaboration for innovation: the advantages of public sector relationships in innovation might be a motive to lose interest in absorbing spillovers from a foreign presence.

The influence of the percentage of graduate engineers and other degree holders in the total personnel figure for a firm (SLAB) on technical progress is nil. The same occurs when multiplying the percentage of such graduates in a firm's staff (SLAB) with foreign presence (PRE). These results give no indications that confirm Hypothesis 10, which states that the quality of human capital improves absorptive capacity from FDI. This may be so because the quality of human capital in Spanish manufacturing firms is not sufficiently high to be a major element in the capacity for absorption of spillovers from foreign companies.

The variable representing the interaction of family control (FAMI) with foreign presence in the sector (PRE) has a negative coefficient of −0.11 on technical progress. The significance is moderate, with a value of 0.068. Hence, Hypothesis 11 can be accepted. Moreover, this relationship is negative. In other words, family control reduces absorptive capacity from FDI. Companies managed by non-family members are better able to absorb the spillovers from FDI mentioned.

The complexity of the production process (PROC) affects technical progress negatively (−0.0199 with moderate significance). Consequently, complex production processes have negative effects on technical advances. Thus, the more complex a production process is, the smaller the yield from the firm's production factors, because the economies of scale decrease.

In contrast, the interaction of the complexity of the production process (PROC) with foreign presence in the sector (PRE) reaches a significant coefficient of 0.032 on technical progress. This result supports the predicted positive relationship between complex production processes and absorptive capacity as shown in Hypothesis 12. In this way, because foreign firms that implement FDI usually have more complex production processes than do local enterprises, local businesses with similarly complex production processes may be better able to glean technical knowledge from foreign companies through spillovers.

The degree of concentration in the main market (CDOM) has no effect on technical progress, and neither does the variable arising from multiplying CDOM with foreign presence (PRE). This estimation provides no support for Hypothesis 13, which suggests that market concentration favors absorptive capacity from FDI. This outcome may be due to the fact that market concentration in Spain is similar to that of other markets in which foreign firms operate. Hence, local market concentration would not have sufficient weight to affect absorptive capacity from FDI.

Wang et al. (2012a) shows that local firms in low-technology industries (measured by the ratio of R&D to sales) are better at accommodating and absorbing rapid entrances of foreign competitors in the same industry. Whereas our results show that R&D activity and complex, innovative production processes increase absorptive capacity of foreign and local firms from FDI. This suggests that, firms in high-technology industries improve their absorptive capacity when foreign competitors enter the industry slowly.

6. Concluding remarks

Absorptive capacity of spillovers from FDI is a source of technical progress, and our results align with previous studies. Because we consider the determinants that affect technical progress and its relationship with absorptive capacity from FDI, we update and extend the literature to the factors determining the firm behavior, capabilities, and structures that drive absorptive capacity from FDI in Spanish manufacturing firms.

We estimate a model on the basis of a production function to explain the factors determining absorptive capacity from FDI and the effect of each of these factors individually on added value (output). We use GMM estimation for panel data at the firm level in 20 industries over 13 years.

We add to the Barrios and Strobl (2002) proposed production function, which includes the effects of foreign capital and foreign presence on added value (output). We add the effects of R&D activities and expenditures, R&D results, the internal organization of innovation, the external links for innovation, the quality of human capital, family management, and the complexity of businesses and market concentration. In turn, our model considers each of these items in light of foreign presence. These combinations determine absorptive capacity from FDI.

Specifically, we find that R&D activities boost the generation of new knowledge and absorptive capacity from FDI. Internal R&D activities have the most positive effect; externalized activities have a negative impact. This explains the decision to outsource R&D for minor innovations that require nonspecific investments; it makes only a minor contribution to the absorptive capacity of the firm.

We also find a negative link between public funding and absorptive capacity from FDI. This result is consistent with the fact that public financing of R&D is less effective than private funding (Griliches, 1986), and it supports the notion that the companies that manage to find private financial resources are more capable of absorbing spillovers from FDI.

Additionally, we find a negative relationship between family management and absorptive capacity. This is why companies run by people who are not members of the same family are better at absorbing the spillovers from FDI.

Other factors determining absorptive capacity from FDI are complexity and production-process innovations. Complex and innovative production processes makes more and better tools available for absorbing the spillovers from FDI. This is because the firms implementing FDI usually have more complex, innovative production processes than local companies, which helps the absorb more from similarly complex, innovative foreign firms. We confirm that a firm with a complex, innovative production processes has capacity for apply and produce knowledge. So, this capacity shows up in the absorptive capacity of external knowledge from FDI.

Despite these significant contributions to the literature, several constraints should be taken into account. First, it is possible to include the relationship between absorptive capacity from FDI and subcontracted/outsourced manufacturing. Outsourcing may affect absorptive capacity depending on, for example, the type of activity or the communication flow. Second, this study can be extended to include geographical location of foreign firms relative to local companies. Distance determinants such as culture, physical location, or institutional differences may influence absorptive capacity from FDI. Third, further research could incorporate the vertical relationships of industries and businesses (that is, with suppliers and clients). This relationship may influence absorptive capacity from FDI depending on the type of vendor agreement, product supplied, or negotiation power.

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