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## **Exploitative Learning by Exporting**

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### **Abstract**

Decisions on entering foreign markets are among the most challenging but also potentially rewarding strategy choices managers can make. In this study, we examine the effect of export entry on the firm investment decisions in two activities associated with learning about new technologies and learning about new markets ? R&D investments and marketing investments, in search of novel insights into the content and process underlying learning by exporting. We draw from organizational learning theory for predicting changes in both R&D and marketing investment patterns that accompany firm entry into exporting and link these changes to firm productivity. Our results show that marketing investments are equally likely to be triggered by exporting as R&D investments. Furthermore, our results suggest that although export entry is accompanied by increases in both R&D and marketing expenditures, it is predominantly the marketing-related investment decisions associated with starting to export that lead to increases in firm productivity. We conclude that learning-by-exporting might be more properly characterized as ?learning about and exploiting new markets? rather than ?learning about new technologies? as prior research often assumed.

# Exploitative Learning by Exporting

## ABSTRACT

Decisions on entering foreign markets are among the most challenging but also potentially rewarding strategy choices managers can make. In this study, we examine the effect of export entry on the firm investment decisions in two activities associated with learning about new technologies and learning about new markets – R&D investments and marketing investments, in search of novel insights into the content and process underlying learning by exporting. We draw from organizational learning theory for predicting changes in both R&D and marketing investment patterns that accompany firm entry into exporting and link these changes to firm productivity. Our results show that marketing investments are equally likely to be triggered by exporting as R&D investments. Furthermore, our results suggest that although export entry is accompanied by increases in both R&D and marketing expenditures, it is predominantly the marketing-related investment decisions associated with starting to export that lead to increases in firm productivity. We conclude that learning-by-exporting might be more properly characterized as “learning about and exploiting new markets” rather than “learning about new technologies” as prior research often assumed.

**Keywords:** Learning-by-exporting; productivity; exploration and exploitation

## **1. Introduction**

The decision to enter a foreign market is among the most crucial strategic choices managers face both in terms of challenges and opportunities for firm performance. An especially intriguing part of firm internationalization is the idea that firms might learn from foreign environments by conducting business abroad. Accordingly, the topic receives much attention in current strategy and international business literature (Salomon & Shaver, 2005; Salomon & Jin, 2010). The learning effects for firms build on the principle that spillovers of valuable knowledge tend to be highly localized (Jaffe, Trajtenberg & Henderson, 1993). Interacting with carriers of valuable knowledge abroad, e.g. leading customers or competitors, allows firms to tap into valuable knowledge which is not available in their home countries (Ghoshal & Bartlett, 1990; Chung & Alcácer, 2002). This topic is widely studied for foreign direct investment (FDI) and multinational companies (MNCs) (Shaver & Flyer, 2000). However, the vast majority of firms interacts with foreign markets through exporting. Export markets can also serve as a source of knowledge spillovers. Firms get in touch with new information not available in their home markets. Once this knowledge is transferred back home, it may be used to enhance the exporting firms' overall productivity and innovation. Traditionally, this phenomenon has been labeled as "learning by exporting" (Salomon & Shaver, 2005; Salomon & Jin, 2008, 2010).

The goal of our study is to provide new insights into the particular learning processes and contents of learning by exporting. Extant research has largely focused on learning activities which lead to technological innovation through R&D, new products or patents. Yet, this is not the exclusive type of learning which can be triggered by exporting. Exporting is likely to be accompanied by market learning, a process well-acknowledged by international business and marketing research. Firms actively engage in acquiring new information about foreign market

characteristics such as customer preferences, distribution channels or local competition, in order to fully exploit the potential of the export market (Petersen, Pedersen & Lyles, 2008). We argue that this market learning is likely to increase overall firm performance by allowing the exporting firm to exploit its existing assets more fully.

Accordingly, we develop theoretical arguments by integrating organizational learning mechanisms into existing models of learning by exporting. We argue that exploitation through market learning is equally likely to be triggered by exporting as exploration through R&D learning. Furthermore, we develop theoretical predictions for why exploitation is equally likely to lead to improved performance in the post-entry period. We suggest that the decision to export affects firms' subsequent investments in market exploiting activities and that these export-induced exploitation investments can be highly productive for the firm as a whole. In other words, we argue that firms learn to exploit from exporting, in addition to technological learning so far analyzed in earlier studies.

Our study also adds to the strategy and internationalization literatures by connecting the learning outcomes of exporting to a more general model of how organizations learn. Exporting is the most commonly used strategy for international expansion, yet the determinants of firms' export decision and behavior have got substantially more attention in the research than its consequences for firm performance (Salomon & Shaver, 2005). We explain the changes that exporting brings in terms of firms' investment behavior more comprehensively and characterize the relative effectiveness of these investment decisions by comparing their effects on firm productivity.

Our results show that although an export decision is accompanied by increases in both R&D and marketing investments, it is predominantly the marketing-related investment decisions associated

with export entry that lead to increases in productivity. Thereby, we shed new light on the ways through which exporting can improve firm performance.

Our theoretical reasoning and empirical tests are designed to eliminate an important source of bias in the existing literature on learning by exporting. Prior research has often times directly linked exports to performance outcomes thus only assuming that performance changes are the result of learning by exporting (see Silva, Afonso & Africano, 2012 for a recent review). Our conceptualization is more complete in the sense that we model the export decision as the trigger for changes in firm investment behavior. We link these changes in investments to the learning outcomes of the focal firm, i.e. its productivity change, once it starts exporting. By tracing firm investment decisions and identifying the changes associated with export entry, we make a first step towards opening the learning “black box”.

Additionally, extant learning by exporting research has used a variety of methodological approaches which made it difficult to arrive at a unified understanding of effects and minimize potential biases (Silva et al., 2012). We combine and integrate a variety of methodological approaches to achieve the latter. First, by considering R&D and marketing investments simultaneously we eradicate potential omitted variable biases. Second, we apply a treatment model to disentangle the investment decisions linked to export decisions from the investments that a firm would have undertaken anyway, i.e. the counterfactual investments in R&D and marketing. In other words, we aim at reducing potential selection biases. Third, we relate these differentiated investments to firm performance (productivity). This approach is superior to simply comparing firm performance before and after exporting because firms may have simply increased their investments following the export decisions but these investments have not necessarily become more productive. The latter effect would be more closely related to realized

spillovers and learning. In sum, we lay out an integrated, multi-layered empirical strategy for testing learning by exporting effects and demonstrate its application. This strategy should be useful for a variety of future empirical studies on this and related topics.

In terms of relevance for practice, we provide impulses for both management and policy making. Entering foreign markets is a risky decision for firms because they face new customers and competitors. Our findings provide managers with a more precise understanding of the kind of learning benefits they can expect from an export decision and that these benefits originate especially from exploitative learning about markets and marketing. Many governments, such as in the United States, have started high profile policy initiatives to encourage domestic firms to become exporters (e.g. export.gov). The US has currently only slightly more than 300,000 exporting firms (U.S. Department of Commerce, 2014). Our study provides new insights into the changes that similar export policy initiatives will bring to firms investment decisions and productivity outcomes. Hence, policies can be optimized.

The rest of the paper is organized as follows. In the next section we discuss our theoretical framework and formulate the hypotheses we propose to test. The third section describes the empirical approach, data and estimations. The fourth part presents the results of the empirical analysis and a number of robustness checks. In the final section we discuss the results and provide some conclusions and directions for future research.

## **2. Theory and hypotheses**

The goal of our theoretical reasoning is to predict (a) the kind of investments triggered by export activity of firms and (b) to what degree those investments differ in their effects on firm performance. For this purpose we integrate theory on organizational learning (March, 1991) with

theory arguments from learning by exporting models (Salomon & Shaver, 2005). We will develop and contrast arguments for why exporting triggers both explorative activities through R&D as well as exploitative activities through marketing. The latter is largely absent in existing theoretical models of learning by exporting. We start out by explaining central constructs and mechanisms.

Export decisions and their consequences are of central importance to management theory and practice (Johanson & Vahlne, 1977; Campa & Guillén, 1999). Exporting enables firms to extend their sales markets beyond national boundaries and often times leads to broader international engagements in the future. During the internationalization process, firms typically move through different stages starting from export operation and advancing to more complex forms of international expansion such as foreign direct investment. Exporting constitutes the initially preferred way of internationalization as it involves comparatively low levels of resource commitments and risks while avoiding complexities from the need to establish subsidiaries abroad (Lu & Beamish, 2006).

Being a relatively inexpensive and straightforward strategy to enter foreign markets, exporting is associated with various benefits. Firms engaged in export activities provide gains for employees in the form of higher pay and better employment conditions, show faster productivity growth and have higher survival chances compared to their domestic counterparts (e.g., Bernard & Bradford Jensen, 1999). Recent research emphasizes export markets as a means to get access to new technological knowledge. Resulting knowledge transfers have been found to improve firm productivity and innovation performance.

Learning by exporting literature particularly emphasizes learning in terms of technological innovation output (see e.g., Alvarez & Robertson, 2004; Golovko & Valentini,

2011; Salomon & Shaver, 2005; Salomon & Jin, 2008, 2010). The underlying explanation behind the export-productivity relationship is typically linked to (a) competitive pressures on export markets and (b) exporting providing channels to foreign pools of knowledge (Silva et al., 2012). The latter is typically assumed to be related to the knowledge spillovers available in the foreign markets which may come from technologically sophisticated buyers, suppliers or competitors (e.g., Clerides, Lach & Tybout, 1998). Such technological information may then be incorporated in the firms' knowledge production function and enable firms to innovate.

Learning about new technological knowledge however is not the exclusive learning process associated with exporting. Along with the export entry, firms start learning about foreign markets, thereby acquiring market knowledge. A majority of literature on learning by exporting does not distinguish between technological and market knowledge. However, the learning content and process is substantially different. Few studies acknowledge the accumulation of market knowledge as a likely outcome of exporting (Salomon & Shaver, 2005; Salomon & Jin, 2010), yet do not theoretically distinguish between the two types of learning. We thus argue that existing models of learning by exporting are incomplete as they do not explicitly incorporate market learning in the learning by exporting models.

Market knowledge originates mostly from customers and competitors (Slater & Narver, 1999). It relates to the preferences of customers and how they are best met, e.g. through which distribution channels or in which packaging. The absence of knowledge about foreign markets has been identified as a major stumbling block for exporting firms in both international business and marketing literatures. Market knowledge is necessary to engage in successful export market exploitation, as it serves to reduce knowledge gaps related to business environments in the foreign markets (Petersen et al., 2008). By acquiring knowledge about local competitors,

technical standards of the local markets, product requirements, local customer needs and expectations, firms may be able to decrease the perceived market uncertainty and effectively exploit the export market opportunities (Lisboa, Skarmeas & Lages, 2013). Similarly, international marketing literature emphasizes the need for firms to invest in adapted or new versions of existing products, matching the requirements and tastes of foreign consumers for becoming successful exporters (Cavusgil, Zou & Naidu, 1993). Although product adaptation strategy for different markets may increase costs, the adapted products may better fit the need of foreign buyers and therefore bring higher margins and generate higher sales (e.g., Calantone, Tamer Cavusgil, Schmidt & Shin, 2004).

We integrate learning by exporting from foreign technology and foreign markets by using the organizational learning model of March (1991). March models learning as an adaptive process in which firms decide to engage in explorative and/or exploitative activities (for extensive reviews see Raisch, Birkinshaw, Probst & Tushman, 2009 or Lavie, Stettner & Tushman, 2010). Explorative activities are characterized by search in novel domains, innovation, distant outcomes as well as risk (March, 1991). Explorative activities are typically undertaken to develop new knowledge (Levinthal & March, 1993). Exploitative activities in turn focus on maximizing returns of existing firm knowledge, e.g. through efficient implementation and execution (Fang & Levinthal, 2009). While learning about new technologies and learning about export markets might both result in increased productivity and new products, the nature of these two activities is fundamentally different. We explore these differences and their theoretical implications in two steps. First, we lay out arguments for why exporting is equally likely to be associated with increased investments in exploration as in exploitation. Second, we develop predictions about the performance effects of each of these export induced investments. In other

words, we argue that firms learn to exploit from exporting, in addition to the exploration effects so far analyzed in existing studies.

### **Investments in exploration and exploitation induced by exporting**

Learning by exporting literature has mainly emphasized learning activities which lead to technological innovation through R&D, new products or patents (Golovko & Valentini, 2014; Salomon & Shaver, 2005; Salomon & Jin, 2008, 2010). All of these activities are explorative in nature. The theoretical rationale is based on the premise that getting in touch with new technological knowledge allows firms to create novel combinations with existing knowledge stocks, resulting in higher productivity and increased innovation output. Thus, export activity triggers learning which in turn leads to further exploration.

We suggest that firms are equally likely to increase their exploitation activities in response to exporting decisions. More precisely, we focus on firms' marketing activities which have often times been related to how firms exploit the economic potential of existing products and competences (for recent reviews see Krasnikov & Jayachandran, 2008 or Song, Droge, Hanvanich & Calantone, 2005). Value for the firm is extracted if a firm can improve the interaction with customers. This can imply that firms increase awareness of products and features, refine product packaging and design as well as tailor pricing or distribution strategies (Webb, Ireland, Hitt, Kistruck & Tihanyi, 2011). These activities are often times summarized as the "4 Ps" of marketing: product (design), place (distribution), price and promotion (Waterschoot & Van Den Bulte, 1992). Unlike learning about new technologies, marketing is directly related to the exploitation of the firm's existing capabilities in the foreign setting. Exporting involves substantial start-up sunk costs (Campa, 2004) which firms have to bear to start the export operations, and which also determine the expectations from the export entry. Export profits are

often considered as the exporting firm's ultimate goal (Lisboa et al., 2013), thus making the need for exploitation of the firms' strengths even higher. Recent empirical evidence is in line with the exploitative view of exporting, showing that firms need to prepare for the entry into exports by e.g. investing in new processes before the actual entry (e.g. Lileeva & Trefler, 2010; Cassiman & Golovko, 2011) to make exporting a successful strategy.

It is therefore very likely that firms will need to increase their marketing activities once they have entered foreign export markets. Customer demands are often times tied to economic, social or even religious conditions in export countries. The latter are rarely fully codified or articulated. Local competitors can tailor their products and practices to such needs in practice over time while foreign competitors will only experience them once they have entered the market (Zaheer & Mosakowski, 1997). This explains (a) why local competitors have better adapted products on foreign markets (Zaheer, 1995) and (b) why local customers form perceptions about foreign products which are not exclusively built on product characteristics (Bilkey & Nes, 1982). We predict that these conditions provide the necessity and opportunity for exporting firms to increase their marketing investments. Firms are pushed by local competition as well as by customer preferences to adjust their design, pricing, distribution and promotion strategies in order to fit customer demands on foreign markets. At the same time, they experience the marketing strategies of foreign competitors along these domains. These demonstration effects on the product market provide ample opportunities to imitate successful competitors. As a consequence, we predict that firms will increase their marketing investments once they enter foreign markets through exporting. We propose:

*Hypothesis 1:* Firms starting to export will have both higher investments in exploration through R&D and exploitation through marketing compared to non-exporting firms.

## **Performance effects of investments in exploration and exploitation induced by exporting**

In a second step we focus on the effects of the export-induced investments in exploration and exploitation on firm performance. Extant learning by exporting literature has mainly focused on the outcomes of explorative investments in R&D such as patented technologies (Golovko & Valentini, 2014; Salomon & Jin, 2008). Within these models, exporting serves as a channel for accessing foreign knowledge pools, be it market or technological knowledge (Salomon & Jin, 2010). A richer knowledge pool would allow firms to generate novel combinations with existing knowledge. The consequence of these combinations is an increase in the novelty of resulting products and creation of new stocks of knowledge and innovations. We argue that it is essential to assess the productivity of the export-induced investments in exploration and exploitation separately, given substantial differences in the learning content and processes associated with market and technology learning.

Krasnikov and Jayachandran (2008) show in a meta-analysis that marketing activities have at least the same potential for creating superior firm performance than R&D investments. Marketing actions such as advertising, service improvements, loyalty programs, can help firms build such long-term assets as brand equity and customer loyalty. Customer behavior influences the market, changing firm's market share and sales (Rust, Ambler, Carpenter, Kumar & Srivastava, 2004), thus directly affecting firm's profits. Marketing initiatives can also be leveraged to increase short-term profitability through e.g. launching new advertising campaigns, promotion strategies, or changing the structure of pricing (Rust et al., 2004).

We ground our theoretical predictions on differences in performance effects on the locus of interaction between the exporting firm and its foreign export market. Exporting differs from alternative modes of internationalization in the degree to which firms interact with foreign

knowledge carriers (Salomon & Shaver, 2005). In this regard, multinational companies (MNCs) have received a lot of attention in recent international business and strategy literature. Local subsidiaries can absorb local knowledge and transfer it across borders because the MNC operates like a social community by providing channels, shared norms and practices for international knowledge flows (Kogut & Zander, 1993). The locations of such subsidiaries within the host country are typically purposefully chosen to maximize the benefits of the interaction between the foreign firm and local knowledge pools, e.g. leading universities (Alcacer & Chung, 2007). This allows foreign firms to create knowledge channels for comprehensive knowledge transfers. Comprehensiveness implies that large parts of relevant knowledge have characteristics of embeddedness, complexity or tacitness (Reed & Defillippi, 1990). For this reason, efficient knowledge transfers of technological knowledge require involving the knowledge carrier or producer, e.g. a university scientist (Agrawal, 2006). Such knowledge exchanges benefit from geographical proximity and the cultivation of channels over time.

These conditions provide significant obstacles for the absorption of technological knowledge for exporting firms. Exporting limits the foreign market involvement. Hence, firms will be mainly exposed to knowledge which is observable in product markets or the products themselves. Under these conditions, firms can access information as long as information is codified or can be obtained from reverse engineering. The opportunities to benefit from these particular types of information are limited. Reverse engineering is only feasible if components and relationships are well understood and available (Reed & Defillippi, 1990). Opportunities for benefitting from foreign knowledge externalities in a firm's R&D may exist as a result of exporting but their potential is limited. The close links with foreign buyers may constitute a potentially important source for technological diffusion to a new exporter (Clerides et al., 1998;

Salomon & Jin, 2010). Yet the relationships with the buyers are not unconditionally beneficial in terms of technological learning. In an OEM supply context, Alcacer and Oxley (2013) show that the type of the customer matters substantially for the realization of technological learning. While engaging with the most sophisticated customers significantly increases suppliers' technological learning, the realized learning depends on the duration of the relationship and the choice of the initial customer which is almost random and involves significant switching costs and inertia (Alcacer & Oxley, 2013).

In contrast, most relevant product market characteristics of export markets are observable. Exporting firms can observe pricing, design, distribution and promotion strategies of competitors. As a consequence firms can adjust their marketing strategies by imitating the most successful ones. Similarly, changes in marketing strategies require typically much lower investments of specialized human resources and time. This allows firms to experiment with different marketing strategies, e.g. alternative pricing strategies, or packaging, and learn from the outcomes quickly and reliably. The fact that marketing strategies and their effects are highly observable increases the odds that they can be transferred to the other markets of the exporting firms. In this regard, certain geographical markets have been identified as lead markets with anticipatory demand conditions for other international markets (for a review see Beise & Cleff, 2004). Hence, the transfer of successful design, pricing, distribution or promotion strategies to the home country can strengthen the exporting company as a whole.

In sum, we predict that the export decision exposes firms to a new variety of customer demands and competitor practices in the first place. The variation mainly occurs in the product market domain which is largely observable for the exporting firm. Hence, firms can learn about new markets and improve the productivity of their marketing activities relatively easily, thereby

increasing overall productivity. The latter may also be possible for explorative investments in R&D but our reasoning leads us to believe that the barriers for efficient knowledge flows are considerably higher. We hypothesize:

*Hypothesis 2:* Firms experience higher productivity increases from export-induced investments in exploitation through marketing than from export-induced investments in exploration through R&D.

### **3. Empirical study**

To test our theoretical predictions we need to establish which parts of a firm's R&D and marketing investments are induced by exporting and how such export induced investments translate into firm performance. We will do so through a combination of a treatment effects analysis and a regression analysis. We will proceed in three steps:

1. We will predict the probability of a firm to start exporting based on a vector of firm characteristics which have been used by prior literature.
2. We will match firms which started exporting with a control group of firms which are similar in all the main characteristics to the focal firm but did not start to export. This allows us to establish the counterfactual information on how much the focal firm would have invested in R&D and marketing if it had not started to export. The differences in investment between focal firm and matched control firm are the export-induced investments in R&D and marketing. Hypothesis 1 is supported if both types of investments are positive and significantly higher than the investments of non-export oriented firms.

3. We estimate the effect of export induced R&D and marketing investment on firm productivity. Hypothesis 2 is supported if the effect of export induced marketing investment on productivity is significantly larger than the effect of export induced R&D investment on productivity.

The section on estimation strategy below provides methodological details on this procedure.

## **Data**

The data we use in this paper come from a survey of Spanish manufacturing firms “Encuesta sobre Estrategias Empresariales (ESEE)” or Survey on Business Strategies during 1996-2009. The project was conducted by Fundación Empresa Pública with financial support of the Spanish Ministry of Science and Technology. The survey is administered to the population of Spanish manufacturing firms with 200 or more employees and to a stratified sample of small and medium sized firms, representative of the population of manufacturing firms with more than 10 but less than 200 employees<sup>1</sup>. The sample aims to maintain the representativeness of the manufacturing sector over time. Additional firms are included in the sample from the population of newly founded firms every year. Firms that exited the original sample during the sampling period are replaced by firms with similar characteristics drawn from the population. The initial sample is an unbalanced panel originating from twenty distinct industries.<sup>2</sup> After dropping missing values, outliers and having forwarded the dependent variable by three periods (to avoid biases originating from simultaneity effects), our final sample contains 10,507 firm-year observations.

The ESEE dataset provides an appropriate setting to test the relationships we intend to examine. First, the dataset allows tracing firms’ export, R&D, and marketing investment

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<sup>1</sup> Size class distribution is reported in Appendix 1.

<sup>2</sup> The ESEE data cover the whole manufacturing sector of Spanish economy and includes 20 industries defined at the 2-digit level. The industry breakdown with the number of firms in each sector is provided in the Appendix 2.

decisions over a long time period. Second, our data cover a timeframe characterized by the opening of the Spanish economy towards international markets. This makes our sample particularly well-suited for examining the decision to internationalize. Finally, the ESEE dataset has been used by prior research on learning by exporting (e.g. Salomon & Shaver, 2005; Salomon & Jin, 2008, 2010; Golovko & Valentini, 2014), which allows us comparing the results to prior studies.

### **Dependent variables**

Our analysis covers several steps. For the first part of our analysis, the dependent variables are marketing and R&D expenditures respectively. The former is measured by the ratio of marketing expenditures to total sales and the latter by the ratio of R&D expenditures to total sales.

For the second part of the analysis the dependent variable is the measure of firm productivity, calculated as the log of the focal firms' annual value added. This value is calculated by subtracting expenditures for raw materials, consumables and services from the firms' sales. Several studies have used alternative performance measures for investigating learning by exporting such as patent counts (e.g. Salomon & Jin, 2010). However, such technological outcomes would bias our results towards R&D and technological spillovers. Productivity measures have the advantage that they capture all forms of learning and innovation (e.g. increased sales due to improved products or lower costs through improved processes), comprehensive measures of firm performance and available across industries. What is more, we induce a three year time lag between the year of the export decision and the observed outcome to account for potential simultaneity effects. The choice of three year time lag is in line with prior empirical studies (e.g., Bernard & Bradford Jensen, 1999, Salomon & Shaver, 2005). As Salomon and Shaver (2005) indicate, it may take some time for learning outcomes to be

incorporated in firm's activities, so the learning benefits of exporting may not be realized until future periods. In sensitivity analyses, we use different model specifications with shorter or longer time lags for the productivity and the results are consistent with the three year lag specification.

### **Independent variables**

For the first part of the analysis we estimate the propensity of firms to start exporting. We use a number of relevant covariates typically used in the literature to model a firm's choice to start exporting: firm size is calculated as the logarithm of the number of firm employees (*LN\_SIZE*) and accounts for the fact that it is often larger firms that decide to export (Bernard & Bradford Jensen, 1999), the percentage of foreign ownership (*FOREIGN*) as firms with a high foreign-owned capital might be more likely to export to the countries that hold their shares (Basile, 2001); a dummy variable which reflects the evolution of the firm's product market to account for more intense competition which may encourage firms to increase their market share through exports (*GROWTH*). We also include a control for the geographical location of a firm within Spain (*LOC*), as firms that are in proximity of a harbor or an airport might have more facilities to export than firms that are located in more remote areas. Finally, twenty industry dummies control for unobserved heterogeneity and technological opportunity across sectors and time dummies, one for each year, are included to capture macroeconomic shocks.

This initial step of the analysis allows us to separate R&D and marketing investments of an exporting firm into a part that was induced by the export decision and a counterfactual part which the firm would have undertaken anyway (see next section for methodological explanation). These differentiated variables, namely export induced R&D investments,

counterfactual R&D investments, export induced marketing investments and counterfactual marketing investments become the central independent variables in the second part of the analysis in which we estimate a production function. As customary in production function estimation we control for the focal firm's physical capital, calculated as the log of firms stock of tangible assets (*LN\_CAPITAL*) and labor, measured by the log number of employees in a given year (*LN\_SIZE*).

### **Estimation strategy**

In order to analyze our hypotheses empirically, we proceed in two main steps. First, we estimate the average effect of exporting on exploration through R&D investment and exploitation through marketing investment (Treatment model). Secondly, we estimate how these effects translate into overall firm productivity (Productivity model).

#### *Treatment model*

We start by estimating the average effect of exporting (the treatment) on firms' exploration through R&D investments and exploitation through marketing investments, respectively. Using a treatment effects analysis allows us to estimate how much an exporting firm would have spent on R&D or marketing if it would not have exported. This counterfactual situation, i.e. expenditures of an exporting firm if it would be in a counterfactual situation of not having exported - is of course never observable and has to be estimated. In order for our estimates to be unbiased, we have to account for the fact that the decision to enter international markets by a firm is not random. A firm that decides to start exporting may differ in important characteristics from a firm that decides to stay local. As a consequence, such selection has to be taken into account. In this study, we account for such selection by using an econometric matching estimator. More precisely, we employ a nearest neighbor propensity score matching.

The matching estimation balances the samples of treated and untreated firms according to the probability of choosing to enter the export market. The probability is obtained from a probit estimation on the probability of switching export status. The matched pairs are then chosen based on the similarity in the estimated probability of choosing to export. The construction of the control group depends on the algorithm chosen to conduct the matching. In our analysis, we conduct a variant of the nearest neighbor propensity score matching, namely caliper matching. Appendix 4 provides more technical information on the matching procedure. For clarity in interpretation we limit the matching to firms which start exporting during our observation period and exclude those for which we cannot observe the switch in export status.

Furthermore, on top of matching on the propensity score, we also require observations of both samples to be from the same year, industry and region, as those criteria seem essential to build comparable groups. This allows us to assign each exporting firm with a matched twin which had the same propensity to start exporting but did not. The R&D and marketing investments of this matched twin will be used as the counterfactual R&D and marketing investments of the focal firm if it would not have started to export. Differences in investments can be interpreted as induced by exporting.

The fundamental evaluation question can be illustrated as follows:

$$\alpha^{TT} = \frac{1}{N^T} \sum_{i=1}^{N^T} (R\&D_i^T - \widehat{R\&D}_i^c) \quad (1)$$

where  $R\&D_i^T$  indicates the expenditure of treated firms and  $\widehat{R\&D}_i^c$  the counterfactual situation, i.e. the potential outcome which a treated firm would have realized if it would be in a counterfactual situation of not having received a treatment. In other words, for the untreated firms,  $\widehat{R\&D}_i^c$  corresponds to their R&D expenditures.  $S \in \{0,1\}$  indicates the switch from being a

non-exporter to being an exporter and  $N^T$  corresponds to the number of treated firms. Marketing expenditures are evaluated similarly.

### *Productivity model*

In a second step, we turn to the analysis of how export induced R&D and marketing investments translate into firm productivity. In order to do so, we separate R&D and marketing expenditures into two components: expenditures which would have taken place even if a firm would have remained active exclusively on the local market ( $\widehat{R\&D}^c$  in the case of R&D expenditures and  $\widehat{Mktg}^c$  for marketing expenditures) and those expenditures that were induced by the fact that the firm went international ( $\alpha^{R\&D_{TT}}$  and  $\alpha^{Mktg_{TT}}$  respectively). To obtain these effects at the individual firm level, we calculate the difference between the overall R&D (marketing) investment and the counterfactual R&D (marketing) investment as follows:

$$\alpha_i^{RDTT} = R\&D_i - \widehat{R\&D}_i^c \quad \text{and} \quad (2)$$

$$\alpha_i^{MktgTT} = Mktg_i - \widehat{Mktg}_i^c \quad (3)$$

For firms that remained active on the national market only,  $\widehat{R\&D}_i^c$  ( $\widehat{Mktg}_i^c$ ) is equal to their R&D (marketing) expenditures, as  $\alpha_i^{R\&D\_TT}$  ( $\alpha_i^{Mktg\_TT}$ ) will be equal to 0.

To estimate the impact of these variables on firms' value-added, we estimate a Cobb-Douglas production function. We augment the classical production function introduced by Griliches (1986) by adding two types of knowledge, namely technological (R&D investment) and market knowledge (marketing investment). Our production function can thus be presented as follows:

$$Y_{it+3} = A^{\alpha t} K_{it}^{\gamma} L_{it}^{\lambda} RD_{it}^{\delta} Mktg_{it}^{\beta} \quad (4)$$

with  $Y$  representing the firm's output, forwarded by three periods in order to avoid direct simultaneity.  $A$  is a constant, measuring total factor productivity (TPF) with  $\alpha t$  being the time

trend in the rate of technical change.  $K$  is a firm's physical capital, calculated as the log of firms stock of tangible assets ( $LN\_CAPITAL$ );  $L$  represents labor, measured by the log number of employees in a given year ( $LN\_SIZE$ ).  $RD$  captures R&D expenditures and  $Mktg$  - marketing expenditures. The parameters  $\gamma$ ,  $\lambda$ ,  $\delta$  and  $\beta$  denote the unknown output elasticities of inputs.<sup>3</sup> In order to obtain a linear form of the above production function, we take natural logarithms.

Even though our outcome variable is forwarded by three periods, therefore ruling out direct simultaneity, it could be argued that our results are impacted by unobserved, time-invariant firm heterogeneity. To take unobserved heterogeneity into consideration, we follow Blundell, Griffith and Reenen (1995) as well as Blundell, Griffith and Windmeijer (2002) et al. (1995, 2002) and use the pre-sample mean of the outcome variable with which firms enter the sample, measured as the firms' added-value in the five years prior to the sample start, i.e. 1990-1995 ( $LN\_preY$ ). Lach and Schankerman (2008) have adapted the original model to the linear case, which we use here. Using a pre-sample mean approach has a series of advantages over using standard fixed effects estimations. Firstly, in order for fixed effect estimates to be consistent, strict exogeneity is required. In our setting it is unlikely that this assumption holds given that firms' sales are likely to influence future decisions on marketing and R&D as well as on labor and capital investment.<sup>4</sup> This problem is addressed by following the pre-sample mean approach, as it does not require strict exogeneity for the estimates to be consistent. Secondly and most importantly in our case, we are not interested in the within but rather in the between firm variation. As a consequence, fixed-effects estimations would not provide an appropriate

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<sup>3</sup> It should be noted that by defining  $Y$  as the firm's value-added, material is taken into account in  $Y$  and we do not have to include it as an additional variable on the right-hand side of the equation.

<sup>4</sup> The null hypothesis of the Wooldridge test stipulating that there is no first-order autocorrelation is significant at the 1% level and can therefore not be rejected ( $F(1,966)=34.079***$ ).

estimator to test out hypotheses. Further, to account for the fact that recent productivity may influence future productivity, we control for value-added<sub>t-1</sub> and value-added<sub>t-2</sub>.

Before turning to the empirical results, Table 1 presents the descriptive statistics of the firms composing our sample. On average, a firm in our sample has a marketing intensity of roughly 1% and an R&D intensity of 0.4%. Furthermore, the average firm in our sample has a size of 40 employees (25 at the median), a foreign ownership of 6%, 25% of the firms estimate that their most important market is growing and roughly 50% of the firms switched from non-exporting to exporting status during our observation period.

*Insert Table 1 about here*

When comparing firms that switched to exporting to firms that remained local, we see that on average exporting firms are larger, have a higher foreign ownership and indicated that their most important market is expanding more often. We further see that switching firms have significantly higher marketing as well as R&D expenditures when compared to non-switching firms. At this stage however, we cannot say how much of these additional expenditures can be attributed to the fact that they switched to exporting and how much is due to other firm characteristics.

Finally, we inspect the dataset for multicollinearity. The average variance inflation factor of the regression model is 1.18 with a maximum variance inflation factor of 1.47. Hence, there is no indication of any biases originating from multicollinearity.

## **4. Results**

Our empirical strategy consists of the combination of a treatment model and a subsequent productivity model. We will present the results accordingly.

*Treatment model*

Our empirical strategy begins with the estimation of a propensity to start exporting (i.e. the exporting decision). Table 2 displays the results of the estimation on the likelihood of entering the export market. In line with previous findings, all the covariates have a significant and positive impact on the export decision.

*Insert Table 2 about here*

The probit estimation allows us to predict a firm specific propensity score for each firm in our sample on the likelihood to start exporting, whether the focal firm has actually decided to start exporting or not. We use this propensity to match each firm which starts to export with a twin firm which had the same propensity to start exporting than the treated firm but did not start exporting. Apart from the propensity score, we assure that observations of focal firm and matched twin are from the same year, industry and region. The goal is to create a matched sample in which exporting firms and matched twins are almost identical.

Table 3 shows the results of the matching estimation. As can be gathered from the t-test on mean differences between the treated (exporting) firms and the control group, all covariates are well balanced after the matching, pointing to the fact that our matching was successful and that we found a close neighbor for all of our treated firms. The only remaining significant differences are in the outcome variables.

On average, treated firms have R&D expenditures that are 0.195% points higher and marketing expenditures that are 0.49% points higher than if those firms would not have started to export. We thus find support for our first hypothesis insofar that we find evidence that firms that start exporting have higher R&D as well as marketing expenditures. We further test whether the export induced effects differ significantly between R&D and marketing but this is not the case.

*Insert Table 3 about here*

### *Productivity model*

We next turn to the estimation on how export-induced marketing and R&D investment turn into firm productivity (Table 4). We account for the unobserved time invariant heterogeneity by controlling for pre sample productivity mean (Models 1-3) and feed forward effects with different time lags (Models 2-3). We observe that marketing investments have a positive and significant impact on firm productivity no matter whether they are export induced or not. In the case of R&D expenditures, export induced R&D expenditures are only significant at a 10% level (Model 1), and become insignificant in Models 2-3 when recent feed forward effects are accounted for. We thus find support for our second hypothesis throughout our various estimations<sup>5</sup>. All the other control variables of the production function have the expected signs and significance levels, also consistent with prior research.

*Insert Table 4 about here*

### *Sensitivity analysis*

We conduct a sensitivity analysis to test the robustness of our empirical findings. In particular, we test the robustness of our findings by estimating a Generalized Estimating Equations (GEE), pioneered by Liang and Zeger (1986) and allowing to account for autocorrelation (we use an autocorrelation structure of order 2). In line with the main model, we take recent value-added and pre-sample means into account. Marketing investments are positively and significantly associated with productivity level, while we observe no significant

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<sup>5</sup> We experimented with shorter and longer time lags (up to four years) for the productivity measure. Estimation results are not sensitive to the assumed lags and our findings remain stable over different specifications. The results are available upon request.

effect of export induced R&D investments on productivity. The results of the robustness tests can be found in Appendix 3.

## **5. Discussion and conclusions**

We examine the effect of exports on the investment decisions in two activities associated with technological and market learning, R&D investments and marketing investments, in search of novel insights into the particular learning processes and contents of learning-by-exporting. More specifically, we investigate the changes in R&D and marketing investment patterns that accompany the entry into export markets and relate them to overall firm performance. Our results indicate that marketing investments are equally likely to be triggered by exporting as R&D investments. Moreover, these export-induced investments in marketing are highly productive for the firms, unlike R&D investments. Our results therefore suggest that although an export decision is accompanied by increases in both R&D and marketing investments, it is predominantly the marketing-related investment decisions associated with export entry that lead to increases in firm productivity.

Overall, our results support the hypotheses of this investigation and provide a number of contributions to the literature. Prior studies have often times directly linked exports to the performance outcome thus only assuming that changes in performance are the result of learning-by-exporting. Our theoretical model of learning by exporting is more complete in the sense that we conceptualize the export decision as the trigger for changes in firm investment behavior. We further link these export-induced changes in investments to the learning outcome of the focal firm, i.e. its productivity change, once it starts exporting. By tracing firm investment decisions

and identifying the performance changes associated with export entry, we make a first step towards uncovering the process of “learning-by-exporting”.

Second, our model incorporates market learning as an important part of knowledge accumulation associated with export entry, in addition to technological learning. A majority of prior research on learning by exporting has not explicitly distinguished between technological and market knowledge that export markets can offer, thus confounding the effects of market and technological learning. Yet our empirical results suggest that market learning is a main determinant of productivity improvements. Conceptually, we provide an explanation for the mechanism that underlies the relation between market knowledge accumulation and productivity. Complementing prior research, we thus stress the importance of such market exploiting activities for exporting firms. We thereby contribute to a long-standing debate on the self-selection versus learning hypothesis in the export-productivity link. We show that although exports make firms invest more in R&D activities thus indicating that some technological learning may take place, such export-induced R&D investments do not make firms more productive ex-post. On the other hand, market exploiting activities, as evidenced by increases in marketing investments associated with export entry, directly contribute to the productivity increases in the post entry period. Thus, learning-by-exporting might be more properly characterized as “learning about and exploiting new markets” rather than “learning about new technologies” as prior studies have often implied. Our findings provide a plausible explanation for the absence of evidence on the causal effect of exporting on firm productivity that most learning by exporting literature has documented.

Third, our study provides a methodological contribution by offering a two-step analysis which allows to disentangle the immediate effect of exports on firm investment behavior and evaluate the effects of such changes on subsequent performance. We combine a propensity score

matching with a regression approach to model the two stages of our analysis. Our modelling takes care of endogeneity in the export-performance link, a challenge emphasized by a majority of prior studies on learning by exporting. Moreover, our treatment model allows to disentangle the changes in firm investment decisions, both R&D and marketing, that are explicitly linked to export entry from the investments that a firm would undertake anyway, had it never entered the export market. We also quantify the magnitude of these export-induced changes in R&D and marketing investments. Finally, by relating these differentiated investments to firm productivity, we are able to evaluate the contributions of R&D and marketing investments and particularly, their export-triggered parts, thus making explicit distinction between market learning and technological learning as conceptualized in our theoretical model. In such a way, we offer an integrated multi-layered empirical approach, which can be useful for testing learning by exporting as well as for related topics.

More generally, our study adds to the strategy and internationalization research by connecting the learning by exporting model to a more general model of how organizations learn. We explain the changes in investment patterns associated with exports and characterize the relative effectiveness of these investments by comparing their effects on firm performance measured by productivity. Thus, we provide some new evidence on how exporting can improve firm performance.

In terms of relevance for practice, our findings provide managers with a more precise description of the kinds of learning benefits that can be expected from an export decision. We show that these benefits originate especially from exploitative learning about markets and marketing. Many governments, including Spain and other European Union countries, have started policy initiatives to encourage domestic firms to become exporters. Our study provides

new insights into the changes that similar export policy initiatives will bring to firms investment decisions and productivity outcomes. Hence, policies can be optimized.

While conducting this research we have also learned about potentials for future research. First, our model implies information flows throughout the exporting company, i.e. from export sales to R&D and marketing departments. Dedicated studies may be able to disentangle how these information flows are organized and whether different organizational designs are particularly akin to result in productivity increases. Second, we focus on changes in firms exploitation strategies based on their investments in marketing. Future studies may be able to disentangle what part of the marketing mix is especially likely to benefit from export experience. Finally, our empirical results and especially the sensitivity analyses suggest that the productivity increases due to export-induced marketing investments are particularly persistent over time. Put differently, we find that exporting firms continue to learn from their export experience. Such timing effects have a large potential to inform managers since they hint at a sustainable source of competitive advantage. Explaining these timing effects of exploitative learning by exporting deserves dedicated theoretical explanations and empirical designs. We consider them as particularly fruitful paths for future investigations.

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**Table 1: Descriptive statistics, N=10507**

Variable	Overall sample				By group of interest				T-test on mean difference
	Mean	Std. Dev.	Min	Max	Non-exporting firms N=5224	Std. Dev.	Switching firms, N=5283	Std. Dev.	
<i>MKTG</i>	0.958	2.525	0	53.173	0.637	1.854	1.275	3.014	***
<i>RD</i>	0.403	1.844	0	60.779	0.196	1.147	0.607	2.319	***
<i>LN_SIZE</i>	3.701	1.083	2.485	7.963	3.387	0.802	4.011	1.226	***
<i>FOREIGN</i>	5.665	21.943	0	100	1.482	11.348	9.802	28.213	***
<i>GROWTH</i>	0.249	0.432	0.000	1	0.224	0.417	0.274	0.446	***
<i>ENTRY</i>	0.503	0.500	0.000	1					

**Table 2: Probit estimation on the likelihood of switching from non-exporting to exporting, N=10507**

Variables	Coeff.	Std err.
<i>LN_SIZE</i>	0.478 ***	(0.095)
<i>LN_SIZE2</i>	-0.013	(0.011)
<i>FOREIGN</i>	0.007 ***	(0.001)
<i>GROWTH</i>	0.062 **	(0.031)
<i>CONSTANT</i>	-6.641	(123.609)
Log-likelihood		-6204.3786
Joint significance of sector dummies		$\chi^2 (19) = 527.42^{***}$
Joint significance of region dummies		$\chi^2 (7) = 216.23^{***}$
Joint significance of time dummies		$\chi^2 (13) = 142.88^{***}$

Notes: \*\*\* (\*\*, \*) indicate a significance level of 1% (5%,10%). The model contains a constant, industry and year dummies (not presented).

**Table 3: Matching results**

Variables	<i>treated firms</i> N = 3819		<i>Selected control group</i> N = 3819		<i>t-test on diff. in means</i>
	Mean	Std. Dev.	Mean	Std. Dev.	
<b>Control variables</b>					
<i>LN_SIZE</i>	3.545	0.897	3.511	0.836	p=0.194
<i>LN_SIZE2</i>	13.373	7.761	13.025	6.940	P=0.981
<i>FOREIGN</i>	0.4713	0.111	0.4713	0.111	p=1.000
<i>GROWTH</i>	0.256	0.437	0.254	0.435	P=0.862

**Outcome variable**

<i>MKTG</i>	0.946	1.972	0.549	1.591	p<0.000
<i>RD</i>	0.413	1.883	0.228	1.181	p<0.000

Notes: \*\*\* (\*\*, \*) indicate a significance level of 1% (5%, 10%). T-statistics are based on Lechner's (2001) asymptotic approximation of the standard errors that accounts for sampling with replacement in the selected control group.

**Table 4. Regression results; dependent variable:  $\ln(\text{value\_added})_{t+3}$**

	Pre-sample mean estimations					
	Model 1		Model 2		Model 3	
$\alpha_i^{R\&DTT}$	0.072	*	0.021		0.013	
	(0.041)		(0.023)		(0.023)	
$\widehat{R\&D}_i^c$	-0.038		0.002		0.007	
	(0.046)		(0.024)		(0.024)	
$\alpha_i^{MktgTT}$	0.058	*	0.033	**	0.028	**
	(0.034)		(0.015)		(0.012)	
$\widehat{Mktg}_i^c$	0.12	***	0.05	***	0.042	***
	(0.042)		(0.017)		(0.013)	
$LN_{(Y_{(t-1)})}$			0.726	***	0.597	***
			(0.031)		(0.031)	
$LN_{(Y_{(t-2)})}$					0.23	***
					(0.020)	
$LN_{(pre\_Y)}$	0.359	***	0.1	***	0.066	***
	(0.043)		(0.021)		(0.018)	
$LN_{CAPTIAL}$	0.023	***	0.007	***	0.005	**
	(0.004)		(0.002)		(0.002)	
$LN_{SIZE}$	0.772	***	0.205	***	0.123	***
	(0.055)		(0.031)		(0.028)	
$CONSTANT$	5.771	***	1.616	***	1.033	***
	(0.404)		(0.231)		(0.220)	
Overall model significance (Wlad chi2)	10055.16	***	70551.57	***	100351.3	***
Joint signif of year dummies (chi2(10))	66.05	***	71.85	***	75.11	***
Joint signif of industry dummies (chi2(19))	93.45	***	60.78	***	62.49	***
R2						
N (# different firms)	4638		4638		4600	

Notes: \*\*\* (\*\*, \*) indicate a significance level of 1% (5%, 10%). Standard deviations in parentheses are clustered at the firm level and bootstrapped (200 replications). All models contain industry and year dummies (not presented).

## Appendices

### Appendix 1: Size class distribution

Size classes	Freq.	in %	Freq. switching firms	Freq. non-switching firms
1 < 20 empl.	3213	30.58	1201	2012
2 ≥ 20 empl. & < 50 empl.	4304	40.96	2018	2286
3 ≥ 50 empl. & < 100 empl.	997	9.49	516	436
4 ≥ 100 empl. & < 250 empl.	1069	10.17	717	352
5 ≥ 250 empl.	924	8.79	786	138
<b>Total</b>	<b>10507</b>	<b>100</b>	<b>5283</b>	<b>5224</b>

### Appendix 2: Industry distribution

Industry	Number of firms
Meat products	346
Food and tobacco	1288
Beverages	198
Textiles	950
Leather and footwear	349
Wood and wood products	411
Paper	283
Publishing and printing	766
Chemical products	397
Plastic and rubber products	571
Non-metal mineral products	941
Metallurgy	218
Metallic products	1418
Machinery and equipment	450
Office machinery and computing	205
Electronics and electronic equipment	507
Autos and motor vehicles industry	258
Other transport equipment	189
Furniture	618
Miscellaneous manufacturing	144
<b>Total</b>	<b>10507</b>

### Appendix 3: Robustness check

#### GEE(AR2)

$\alpha_i^{R\&DTT}$	0.011 (0.022)	
$\widehat{R\&D}_i^c$	0.009 (0.023)	
$\alpha_i^{MktgTT}$	0.028 (0.012)	**
$\widehat{Mktg}_i^c$	0.039 (0.013)	***
$LN_{(Y_{(t-1)})}$	0.634 (0.044)	***
$LN_{(Y_{(t-2)})}$	0.266 (0.043)	***
$LN_{(Y_{(t-3)})}$		
$LN_{(pre\_Y)}$	0.038 (0.016)	**
$LN\_CAPITAL$	0.004 (0.002)	*
$LN\_SIZE$	0.066 (0.026)	***
$CONSTANT$	0.614 (0.214)	***
N	4469	

Notes: \*\*\* (\*\*, \*) indicate a significance level of 1% (5%, 10%). Standard deviations in parentheses are clustered at the firm level and bootstrapped (200 replications). The model contains industry and year dummies (not presented).

### Appendix 4: Matching protocol

Several modern econometric evaluation techniques have been developed to address treatment effects estimations when the available unit of observation is individuals or firms that are subject to potential selection bias (see Heckman et al., 1999; Imbens and Wooldridge, 2009, for surveys).

For the sake of our analysis, we use a nearest neighbor propensity score matching. The econometric matching estimator has the advantage over other existing estimation techniques that

it is less demanding in terms of data. The econometric matching does not require panel data such as the difference-in-difference, nor does it impose any functional form or error term distribution assumptions such as for instance selection models. One major assumption of the method is that it only controls for the selection on observables. That is, one has to observe all the necessary characteristics that may influence a firm to choose to start exporting. This condition is known as the Conditional Independence Assumption (CIA) and was introduced by Rubin (1977). Essentially, it means that in order for the matching to be valid, the outcomes have to be statistically independent of the decision to export, conditional on a set of observable characteristics. Given our rich dataset, containing all the main variables typically used in the literature to model export decisions of firms, we believe that this assumption holds in the context of our analysis.

The matching estimation balances the samples of treated and untreated firms according to the probability of choosing to enter the export market. The probability is obtained from a probit estimation on the probability of switching export status. The matched pairs are then chosen based on the similarity in the estimated probability of choosing to export. The construction of the control group depends on the algorithm chosen to conduct the matching. In our analysis, we conduct a variant of the nearest neighbour propensity score matching, namely caliper matching.

Caliper matching aims at reducing the bias by avoiding to match treated firms with control firms above a certain “distance”, i.e. those firms for which the value of the matching argument  $Z_j$  is far from  $Z_i$ . It does so by imposing a predefined threshold  $\varepsilon$ , above which an observation is deleted from the potential control group. More precisely,  $\|Z_j - Z_i\| < \varepsilon$  for a match to be chosen (see Smith and Todd, 2005).

Furthermore, on top of matching on the propensity score, we also require observations of both samples to be from the same year, industry and region, as those criteria seem essential to build comparable groups. Finally, for the matching estimator to be possible, enough common support is needed. In practice, this means that the sample of treated and controls are restricted to common support. We therefore calculate the minimum and the maximum of the propensity scores of the potential control group, and delete observations on treated firms with probabilities larger than the maximum and smaller than the minimum in the potential control group.