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SELECTIVE LEARNING-BY-EXPORTING: FIRM SIZE AND PRODUCT VERSUS PROCESS INNOVATION

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We further examine the 'learning-by-exporting' phenomenon, suggesting that firms gain from the learning opportunity of foreign markets, as they make choices that better fit the specific needs of their innovation strategies. We contend that firm size affects these needs, with large firms being more inclined to pursue process innovations, while SMEs focus on product innovations. Using a panel of Spanish firms (1990–2002), we find evidence consistent with our hypotheses. Large firms engage in more process innovation once they enter export markets, with the effect being most pronounced two years after the entry. SMEs, conversely, start pursuing more product innovation before they enter the export markets. This last pattern seems to indicate an 'innovating-for-export-markets' relationship. Copyright © 2014 Strategic Management Society.

INTRODUCTION

Firms' innovation processes are increasingly relying on externally sourced knowledge (e.g., Arora and Gambardella, 2010; Chesbrough, 2003). Export markets may constitute a particularly advantageous terrain for such inflows, as they allow firms to get in touch with diverse portfolios of knowledge not available in their home markets. *Inter alia*, The World Bank (1997: 74) has contended that 'participating in export markets brings firms into contact with international best practices and fosters learning.' Accordingly, several studies (e.g., Alvarez and Robertson, 2004; Criscuolo, Haskel, and Slaughter, 2010; Salomon and Shaver, 2005a) show that exporting produces a positive effect on firms' innovation performance thanks to what has been labeled 'learning-by-exporting.'

In this article, we aim to examine in more depth the relationship between exports and innovation. Consistent with prior literature, we contend that there exists the opportunity to learn from foreign markets and, thus, to increase firm innovation performance in relation to exports. Departing from prior literature, however, we suggest that firms will proactively exploit the opportunity to absorb and use the knowledge available in foreign markets that better fits with their specific innovation strategies. As firms have different innovation strategies, innovation performance will be differently affected by access to export markets. We characterize firms' innovation strategies by their relative propensity to produce process versus product innovations (e.g., Utterback, 1994). We then argue that firm size is a relevant variable that affects this decision, with large exporting firms being more inclined to pursue process innovations, whereas small and medium enterprises (SMEs) focus on product innovations. We expect this to be the case because size changes the incentives of

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firms in general, but even more so in relationship with the decision to enter export markets: SMEs need to broaden their product lines and large firms aim at increasing their efficiency.

We test our predictions on an unbalanced panel of Spanish manufacturing firms between 1990 and 2002, using a matching estimator to account for the endogeneity of the export decision, as well as parametric techniques. In line with prior literature, we find that exporting has a positive effect on firms' innovation output. Our results also confirm the hypothesized differences in the effects of exports on innovation depending on firms size, with some important distinctions. Large exporting firms engage in more process innovation after the entry into export markets, with the effect lasting for about two years after the entry. SMEs, conversely, start pursuing more product innovations before they enter export markets, with the effect of exporting observed for approximately two years after the entry.

We then run a number of additional econometric analyses in search of further empirical evidence consistent with our theoretical predictions. Our results support the idea that, in SMEs, learning-by-exporting could be mainly characterized as 'learning about foreign markets,' rather than 'learning about new technologies:' SMEs' product innovations developed in relation to exports are mostly driven by the need to adapt to foreign markets. Furthermore, consistent with our claim that large firms are pursuing process innovations to improve their productivity, we show that among firms entering export markets, large firms characterized by relatively low productivity have a higher propensity to produce process innovations in the aftermath of the export decision.

When contrasted with prior related studies, this article presents several elements of novelty that provide a more nuanced picture of the complex relationship between exports and innovation. In particular, we make a first step toward a better understanding of the content of learning in foreign markets and, thus, ultimately of the *type* of the innovations produced in association with exports. In contrast, prior literature has mainly focused on the *quantity* of innovations produced. We also highlight some of the key drivers of the observed variance in the type of innovations pursued. Most importantly, unlike most existing literature on learning-by-exporting, we explicitly posit that exporters do have an active role in absorbing knowledge spillovers available in foreign markets, selecting the knowledge that better

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fits their innovation strategy needs. Showing that firms that *ex ante* are expected to have different innovation strategies obtain different *ex post* outcomes when entering export markets supports the idea that spillovers from foreign markets are not equal for every firm participating in exports, but rather that firms invest to obtain the knowledge they most need. These results carry important implications for theory, managerial practice, and public policy.

The remainder of the article is organized as follows: we briefly review the related literature and present our theoretical framework. We then describe the data and empirical strategy. The results of the econometric estimations follow. We conclude by dis- cussing the implications of our findings.

BACKGROUND

Potential gains from international trade have been studied for decades. Although they have been mostly analyzed at the country or industry level, a number of scholars recently have examined the effects of international trade at the firm level (Melitz and Trefler, 2012). Among these effects, the so-called 'learning-by-exporting' has attracted substantial interest from both economics and management scholars (see Silva, Afonso, and Africano (2012) for a recent review). Learning-by-exporting broadly refers to the phenomenon whereby firms improve their performance after entering export markets thanks to the knowledge absorbed in these markets (De Loecker, 2010; Salomon and Shaver, 2005a). The two related dimensions of firm performance this literature has analyzed are productivity and innovativeness.

The international economics literature has documented that exporting firms, when compared to non-exporting ones, are characterized by significantly higher productivity (see Bernard *et al*., 2007). This very stream of literature, however, has also highlighted that the actual direction of causality between exports and productivity is still unclear. Several studies support the 'self-selection' hypothesis. These studies have argued that while exporters are generally characterized by higher productivity, this positive correlation can often be explained by more productive firms self-selecting into foreign markets, and not by exporters increasing their productivity thanks to the learning process in foreign markets (e.g., Clerides, Lach, and Tybout, 1998; Bernard and

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Jensen, 1999). Due to the existence of substantial start-up costs to become an exporter and potentially higher competition in export markets, only those firms that are *ex ante* efficient enough to bear these costs decide to start exporting.

A different hypothesis, in principle compatible with the mechanism just described, suggests that exporters may (also) increase their efficiency after they enter export markets, as they learn from international trade activities. Using a sample of Slovenian firms, De Loecker (2007) finds that export entrants become more productive once they start exporting, and Van Biesebroeck (2005) provides evidence of exports increasing firm productivity for a sample of sub-Saharan African firms. Similarly, Lileeva and Trefler (2010), studying a sample of Canadian manufacturing plants, find that plants induced to export because of improved access to the U.S. market display an *ex post* productivity increase.

Even stronger results along these lines are obtained if, rather than analyzing the effect of exports on productivity, the effect of exports on firm innovation performance is considered. Alvarez and Robertson (2004) find a positive relationship between exporting and the probability of innovating, and Salomon and Shaver (2005a) find that a firm's export activity is positively associated with an *ex post* increase in the number of innovations and patent applications. What is more, this literature has highlighted the advantages of innovation output measures as (indirect) indicators of firm learning (e.g., Salomon and Shaver, 2005a). Arguably, it may take some time before the technological information acquired abroad is incorporated into the production function of a firm so as to translate into a tangible productivity growth. New technologies or information about new products are expected to show up earlier in innovation output measures than in productivity indicators. Innovation output can, therefore, be considered a less noisy proxy for learning-by-exporting than productivity indicators (Salomon and Shaver, 2005a).

Despite the fact that learning-by-exporting has gained empirical credibility, the literature has not yet reliably established what firms actually learn from these markets and how they do it. Mostly anecdotal evidence suggests that firms gain access to new technologies of production and new product features by getting in touch with their foreign counterparts. For example, Evenson and Westphal (1995: 2264) suggest that '. . . a good deal of the information needed to augment basic capabilities has come from

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the buyers of exports who freely provided product designs and offered technical assistance to improve process technology in the context of their sourcing activities.' Rhee, Ross-Larsen, and Pursell (1984: 41) report that 'the important thing about foreign buyers . . . is that they do much more than buy and specify . . . Foreign buyers and suppliers provide access to information about what product styles are wanted and about how to make products of a desired style.' Aw and Batra (1998) document substantial inflows of knowledge to exporting Taiwanese firms, which comes through the constant adaptation of their production methods to the specifications provided by foreign purchasers.

In sum, previous literature suggests that export markets provide a variety of knowledge spillovers and information on product features as well as production technologies, which firms can incorporate to improve their innovation performance.

A few studies have begun to examine the possible variance across firms in this learning process. For instance, scholars have argued that the enhancing effect of exporting may depend on firms' specific export markets (e.g., Salomon, 2006) or on their absorptive capacity matured through export experience and the availability of highly skilled individuals (e.g., Albornoz and Ercolani, 2007). Still, prior literature generally assumes that firms are simply exposed to novel external stimuli and knowledge, and variance in learning outcomes across firms is not modeled as the result of firm decisions. That is, these studies have not explicitly considered firms' proactive behavior to capture and exploit the spillovers available in export markets. In this article, we make different—and possibly more realistic—assumptions.

HYPOTHESES

Our reasoning hinges upon two main premises. First, we contend that if firms, as prior literature has shown, can tap into a pool of novel and valuable knowledge by entering into foreign markets, they will actually select, absorb, and use the knowledge that better fits the specific needs of their innovation strategy. Accordingly, the specific effect of entering export markets on a firm's innovation performance will differ precisely depending on its innovation strategy. Second, although past related literature has often identified a firm's innovation strategy as its propensity to produce innovations *tout court*, we submit we could usefully characterize and qualify a

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firm's innovation strategy by its relative preference with respect to product versus process innovations. These two typologies of innovations differ significantly in their intrinsic features and effects and, as a consequence, are predominantly sought by different firms at different timings of their life cycle (Cohen and Klepper, 1996; Klepper, 1996; Utterback, 1994).

On the basis of these premises, the next step is to identify the factors that shape the relationship between firms' entry into export markets and their relative preference in terms of product and process innovations.

Process and product R&D increase the firm's price-cost margin on the output sold to current and prospective buyers. Yet it is generally assumed that process innovation lowers the firm's average cost of production, whereas product innovation increases the price buyers are willing to pay by adding or improving features for a given product. Both effects are related to the presence in export markets. Bernard *et al*. (2007) highlight that exporting firms, when compared to similar but non-exporting organizations, display two key differences. First and as already mentioned, exporting firms are characterized by a higher productivity and efficiency. Second, they commercialize a significantly higher number of different products. Although both of these features characterize exporting firms, some of these firms might experience a stronger incentive to improve their efficiency, whereas others have an incentive to enlarge their offer in terms of products. In this respect, we start by positing that small firms that enter export markets have a higher propensity to produce product innovations when compared to both non-exporting SMEs and large exporting firms.

Previous literature (e.g., Klepper, 1996) suggests that product innovation may be expected to generate higher growth in output than process innovation. As a consequence, in their quest for growth, small firms may devote relatively more effort to product than to process innovation when compared to large firms (Fritsch and Meschede, 2001). This preference becomes even stronger when SMEs face export markets.

Product innovation has been often associated with the decision to start exporting (e.g., Basile, 2001; Becker and Egger, 2013). This link is especially true for SMEs. Small innovating firms are more likely to enter the export market, as well as become successful exporters, compared to their home counterparts because innovation enables them to meet the demand of its changing domestic and international markets,

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making exporting more profitable (Zahra and Covin, 1994).

The need for product innovation in the export context also becomes relatively stronger for smaller organizations compared to larger firms. First, small firms are more narrowly focused compared to their larger counterparts. Hence, they have to invest to adapt their existing products or create new ones in order to successfully enter and operate in the export markets, fulfilling the requirements and tastes of foreign consumers (Cavusgil, Zou, and Naidu, 1993; Calantone *et al*., 2004). Cooper and Kleinschmidt (1985) have shown that adapting to foreign markets through product innovation is relatively more important for young and small firms. Second, product innovation is also particularly important for small exporting firms because it helps them mitigating price discrimination in export markets. There is, in fact, ample evidence that the 'law of one price'—i.e., that identical products sell for the same common-currency price in different countries—does not hold (Goldberg and Knetter, 1997): foreign markets frequently generate lower markups when compared to domestic markets (Bughin, 1996). Competition, costs related to exporting, and lack of market power are among the most frequently suggested drivers of the observed lower markups. And these differences are particularly strong for smaller firms. Aw, Chen, and Roberts (2001) have shown that much of the heterogeneity in the difference between export and domestic pricing is due to differences in prices across firms in the same product markets, and differences across markets are relatively unimportant. This within-market variation reflects differences in product attributes and quality. In turn, differences in quality may be explained by investments in product innovation (Braymen, Briggs, and Boulware, 2011). Hence, if by entering export markets firms can tap into a diverse portfolio of knowledge, we expect that small firms focus on knowledge that improves their ability to produce product innovations.

By contrast, we expect large exporting firms to be particularly incentivized to absorb, use, and invest in knowledge that will allow them to pursue process innovations to improve their efficiency.

Prior literature (e.g., Cohen and Klepper, 1996) has shown that firms experience an increased incentive to pursue process R&D relative to product R&D as they grow larger. The intuition is that large firms prefer to engage in those types of innovation that depend more heavily on existing output for their exploitation, as process innovation does. Assuming

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investing in process R&D entails a fixed cost, by spreading the costs of their process R&D over a greater output, larger firms can appropriate more value from it and, therefore, they have a greater incentive to invest in process R&D as compared to small firms (Klepper, 1996).

If large firms are *ex ante* more inclined toward process innovation than SMEs, exporting large firms will experience an even stronger incentive to invest in this innovation type, as entering foreign markets further enlarges their size. Efficiency is of paramount importance in the export process. Exporting entails specific sunk costs which may include the cost of packaging, upgrading product features, establishing marketing channels, and accumulating information on demand sources (e.g., Roberts and Tybout, 1999). And large firms are in relatively greater need of enhancing their efficiency: the observed productivity advantage of large firms is often due to market power and not to actual technical efficiency (Foster, Haltiwanger, and Syverson, 2008). Revenue-based measures have overestimated incumbents' and old firms' productivity advantages, which actually have lower productivity in terms of output and, thus, need to invest to enhance productivity, as market power is less likely to work in export markets.

Taken together, our arguments lead to the following two hypotheses:

Hypothesis 1. For large firms, entering export markets is associated with an increase in process innovations.

Hypothesis 2. For SMEs, entering export markets is associated with an increase in product innovations.

DATA, VARIABLES, AND STATISTICAL APPROACH

Data

The data we use in this article come from a survey of Spanish manufacturing firms during 1990–2002. 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 firms representative of the population of manufacturing firms with more

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than 10 but less than 200 employees. The sample aims to maintain the representativeness of the manufacturing sector over time. Every year new firms are included in the sample from the population of new firms. Firms that exited the original sample during the sampling period are replaced by firms with similar characteristics drawn from the population.[1]

The initial sample is an unbalanced panel with 2,188 firms in 1990 and 3,462 firms in 2002 coming from 20 distinct industries[2] with 37,141 firm-year observations. Due to missing values, the sample is reduced to 23,226 firm-year observations. With included lagged values of independent variables, the final sample is reduced to 19,737 firm-year observations.

The ESEE dataset provides an appropriate setting to test the relationship between exports and innovation that we aim to examine. First, the data allow tracing the firms and their export and innovation decisions over a time period of 13 years. Second, exporting firms constitute a large proportion of the sample and show considerable variation in their exporting behavior over time. Third, our data cover a time frame characterized by the opening of the Spanish economy to international markets. This makes our sample particularly well suited for examining the decision to internationalize. Fourth, there are very few firms (about 0.2% of the sample) with foreign direct investment. In this way, we are able to focus on exports, without confounding effects of other internationalization strategies. Furthermore, the sample contains detailed information on the firms' innovation behavior, which displays substantial variation across firms and over time. Previous research has used the same dataset, as it is representative for the Spanish manufacturing sector over this period (e.g., Campa, 2004; Golovko and Valentini, 2011; Salomon and Shaver, 2005a, 2005b; Salomon and Jin, 2008, 2010; Shaver, 2011).

[1] The average proportion of the firms in year t that continue in the survey in year t+1 is approximately 91.4 percent for the 1990–2002 sample period. About 8.6 percent of firms exited the sample during this time period. Among the firms that exited the sample, approximately 2.2 percent disappeared due to closure, change to nonmanufacturing activities, and absorption during merger or acquisition. Approximately 2.9 percent of the exiting firms stopped collaborating, and about 3.5 percent were without access due to temporary closure or nonlocalizability.

[2] The ESEE data cover the whole manufacturing sector of the Spanish economy and include 20 industries defined at the two-digit level. The industry breakdown with the number of firms in each sector is provided in the Appendix.

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Key variables

In this study, we examine the relationship between innovation and exports. We are specifically interested in assessing whether firm size plays a significant role in differentiating the effect of exports on innovation. For each firm and for every year, we know whether a firm innovated in product or process and/or whether it exported (for a full definition of the variables see the Appendix). Our dependent variables—*Product innovation* and *Process innovation*—are dummy variables that are equal to '1' if a firm reported product or process innovation occurring in that year and '0' otherwise. Our key independent variable is firm export status, which equals '1' if a firm exported in that year and '0' otherwise.

We defined size categories—large versus small and medium firms—based on industry median size. For each industry, we assigned a firm to a group of SMEs if its size, measured as a number of employees, was lower than the median size in its specific industry. By the same token, a firm was assigned to a group of large firms if its size was greater than or equal to the median size in its industry.[3]

Statistical approach

Our arguments posit that firm size influences the differential effect of exports on the type of innovations pursued—product versus process. Large firms that start exporting may be more prone to invest in process innovation, while for small firms, exporting activity is associated with investments in product innovation. To test these arguments, we perform a split-sample analysis (Venkatraman, 1989; Salomon and Jin, 2008),[4] separating large firms from SMEs. If (large and small firms). Furthermore, as our dependent variable is dichotomous, interpreting interaction terms in nonlinear models like probit becomes problematic (Ai and Norton, 2003).

[3] An alternative definition of size categories is provided in the ESEE survey. Small and medium enterprises are those firms that had 200 or fewer employees in 1990, while large firms are defined as those firms that had more than 200 employees in 1990. The results of the empirical analyses we will present are virtually the same if the ESEE definition size is used. Moreover, the correlation between the size variables based on the two different definitions is 0.75.

[4] Venkatraman (1989) suggests that when researchers explore the different effects of certain strategies across different contexts, they should use subgroup analysis. Salomon and Jin (2008) mention two general means to assess the contingency effects, either by using multiplicative interaction terms or by creating subsample splits based on the median or mean of the moderating variable (Salomon and Jin, 2008:137). We then follow this approach and divide our sample into two subgroups

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size has a moderating effect on the link between exports and innovation, we expect to observe: (1) a positive association between entry into export markets and process innovation in the group of large firms; and (2) a positive association between entry into export markets and product innovation in the group of SMEs.

We start by looking for the simple empirical patterns associating export, type of innovation, and firm size. Specifically, we examine whether exporters differ significantly from non-exporters in their innovation activities, and we trace longitudinally the innovation output of entrants—i.e., firms that start exporting—to assess the potential effect of exports.

This analysis, however, does not take into account other variables that may influence firm innovation decisions. To measure the effect of exports on innovation, the ideal experiment would be to compare the innovation output of a firm after it started exporting with the innovation output of the *same firm* had it never exported. Yet we cannot observe the counterfactual outcome—what would have happened if a firm had not exported, provided that a firm engaged in exporting. To deal with this problem, which is inherent in the evaluation of the effect of any treatment from observational data, we adopt different empirical strategies. First, we use a matching estimator (e.g., Imbens, 2004). Matching estimators impute the missing potential outcomes of treated individuals (i.e., for the purposes of this article, what would have happened in terms of innovation performance to exporters had they decided not to export) using the outcomes of individuals with similar values of 'relevant' pre-treatment variables, but that were *not* exposed to treatment (i.e., firms similar to the ones that started exporting but that did not actually export). Several matching estimators exist (see Imbens (2004) for a review). In this article, we use the matching estimator developed by Abadie and Imbens (e.g., Abadie *et al*., 2001; Abadie and Imbens, 2002). This matching estimator may be biased in finite samples when there is at least one continuous variable on which to match or, in general terms, when *exact* matching is not always possible. To alleviate this problem, Abadie and Imbens (2002) deve- loped a bias-corrected matching estimator, which adjusts the difference within the matches for the differences in their covariate values. Following Abadie and Imbens (2002), we estimate a matching estimator with replacement and four

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comparison units[5] using a Stata routine (Abadie *et al*., 2001).

Control units are selected on the basis of their proximity in the space of a number of relevant matching covariates, drawn from extant literature on exports: *R&D intensity*, measured as the percentage of R&D investment on total sales (e.g., Cavusgil and Nevin, 1981; Basile, 2001); an additional indication of firm size (*Size*) using the logarithm of sales (Bernard and Jensen, 1999; Sterlacchini, 1999); foreign ownership (Basile, 2001) (*Foreign capital*); import status (e.g., MacGarvie, 2006); a dummy (*Growing market*) that reflects the evolution of the firm's product market—the dummy variable equals '1' if a firm perceives its market as a growing one. We also include the set of dummy variables to control for the geographical location of a firm within Spain, as some locations may be more favorable for starting exports, e.g., due to closeness to the sea or country borders, as well as the vectors of industry and year dummies. Bias correction for imperfect matching is implemented for two relevant variables: firm size and R&D intensity.

To find additional econometric evidence (admittedly, mostly correlational in nature) consistent with our theory, we also conduct some parametric analyses. For the subsamples of large and small firms, we estimate a regression model to test for the effects of the export decision on the product/process innovation decisions previously observed for the matching estimation.

The choice of the econometric (panel) model is complicated by a number of factors. Most importantly, we first need to take into account the binary nature of our key variables—export and innovation decisions. Second, research has shown that these decisions, and exports in particular, exhibit some persistence (e.g., Campa, 2004) and may create serial correlation in the data. Third, the decisions to innovate and export may be simultaneously determined (e.g., Melitz and Costantini, 2007) by unobserved firm characteristics, leading to the adoption of both strategies simultaneously and, thus, to the correlation of independent variable (exports) with the error term. We try to account for these issues in different ways.

First, we tested for possible serial correlation in the data by applying the test discussed in Wooldridge

[5] Using a Monte Carlo simulation, Abadie and Imbens (2002) find that the bias-adjusted matching estimator they propose is, in fact, best with four matches in terms of root-mean-squared-error and median-absolute-error.

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(2002) and Drukker (2003): indeed, the test confirms the presence of autocorrelation with $p < 0.001$. Thus, we use models with the disturbance term modeled as an AR(1) process. Second, we ran a Hausman test to decide whether to run a random or a fixed effects model. Results indicate that the null hypotheses is not violated (p-value > 0.1 in all cases), hence we run a random effects model. We then estimate (random effects) linear probability models assessing firms' propensity to innovate. We use one-year and two-year lagged values of the export variable with lags $(t-1)$ and $(t-2)$. By inserting lagged values of exports, we can also check for the differences in the temporal effect of export on innovation decisions (analogously to the matching estimator). Finally, the export variable is instrumented in an effort to account for potential endogeneity problems.

We instrument the choice of the export strategy with a first-stage random effects linear model to use the predicted values in the second-stage innovation regression. We adopted a linear probability model because Angrist (2001) suggests that using linear probability models in both stages gives consistent estimates in the second stage. Also, Horrace and Oaxaca (2006) show that when the predicted probabilities lie between 0 and 1, the linear probability model does not produce biased estimates. Thus, we employ the following specifications:

$$Export_{it} = f(X_{it}; \beta_1)$$

$$Product\ innovation_{it} = f(Export_{it-1}, Export_{it-2}, Z_{it}; \beta_2);$$

$$Process\ innovation_{it} = f(Export_{it-1}, Export_{it-2}, Z_{it}; \beta_3)$$

where:

(X_{it}), (Z_{it}) are sets of variables;
β_j are vectors of parameters to be estimated.

In particular, the first-stage export regression uses the exchange rate (*Exchange rate index*)[6] as an potential export markets. For exporting firms, the information on the export markets is provided in the ESEE survey. The

[6] Following Campa (2004), we calculate an exchange rate index that reflects the changes in the Peseta (the Spanish national currency over the period of analysis) with respect to other foreign currencies during 1990–2002, with higher values of index corresponding to Peseta depreciation periods. This index is firm specific, i.e., it accounts for the fact that different firms may export to different markets and, thus, may be differently affected by the exchange rate changes. It is calculated as a weighted average of the bilateral exchange rates of each of the

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Table 1. Summary statistics for the three subsamples of firms

	Large firms			Small and medium firms		
	1 Exporters	2 Non-exporters	3 Entrants	4 Exporters	5 Non-exporters	6 Entrants
Number of employees	853.14	375.68	529.77	133.29	27.33	52.68
	(1,568.05)	(250.56)	(408.65)	(145.9)	(32.04)	(74.14)
Import (0/1)	0.94	0.57	0.83	0.80	0.15	0.48
	(0.22)	(0.49)	(0.37)	(0.39)	(0.36)	(0.49)
Foreign capital (0/1)	0.50	0.17	0.38	0.28	0.01	0.09
	(0.50)	(0.37)	(0.48)	(0.45)	(0.12)	(0.29)
R&D intensity (divided by sales %)	1.06	0.66	1.15	0.97	0.14	0.46
	(2.23)	(4.55)	(3.81)	(2.51)	(1.11)	(1.88)
Product innovation (0/1)	0.42	0.20	0.34	0.32	0.10	0.21
	(0.49)	(0.40)	(0.47)	(0.46)	(0.30)	(0.40)
Process innovation (0/1)	0.51	0.27	0.46	0.37	0.18	0.28
	(0.49)	(0.44)	(0.49)	(0.48)	(0.38)	(0.45)
Total # of firm-year observations	4,546	224	848	5,415	6,435	4,229

Standard deviations in parentheses.

instrument to predict the decision of a firm to enter the export market. The international trade literature shows that exchange rate fluctuations can significantly affect firms' export behaviors (Basile, 2001; Campa, 2004). Home currency devaluation is expected to result in more firms entering the export market as well as increased export sales for already exporting firms.

RESULTS

Descriptive statistics

Table 1 presents the summary statistics of relevant firm-level variables for our sample. We split the full sample into three subsamples: exporters (firms that

survey data distinguish among three broad export markets—EU (European Union) countries, other OECD countries, and the rest of the world. The computation of the exchange rate index is complicated as the survey reports the information on the markets once in four years, i.e., we have these data for 1990, 1994, 1998, and 2002. We calculate individual exchange rates for firms that were exporters in 1990, 1994, 1998, and 2002 by taking their export market to be equal to the one in the previous period. That is, for 1991–1993, we use the data on 1990, for 1995–1997, we use the information available in 1994, for 1999–2001, we use market destinations in 1998. For the firms that did not export in 1990 (1994) but exported in 1994 (1990), we define their markets as their 1994 (1990) pattern. The same procedure is applied to other combinations of 1990, 1994, 1998, and 2002. For firms that did not export during 1990–2002, we compute a weighted average of the EU, OECD, and other country's shares for Spain in that particular year.

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exported the entire period), non-exporters (firms that did not perform any exporting), and 'switchers' (firms that switched their exporting status during the 1990–2002 period). Among the firms that switched their exporting status, we chose those firms that changed their exporting status from non-exporters to exporters at least once ('entrant' firms).[7] The 'exiters,' i.e., those firms that reported exporting activities at the beginning of the sample period but then stopped exporting

[7] 'Entrants' are the firms that did not export at the beginning of the sample period, then started exporting and stayed in the export market for at least two years. In turn, the subsample of entrants includes two types of firms. First, there are 'strict entrants,' i.e., those firms that did not export at the beginning of the sample and once they started exporting, they continued doing so until the end of the sample period. Second, there are also 'switching entrants,' i.e., firms that did not export at the beginning of the sample period, began exporting some time during 1990–2002, and then stayed in the export market for at least one year. These latter firms can stop exporting and might reenter the export market (or not). As exporting activity is generally characterized by persistence (e.g., Campa, 2004), i.e., if a firm enters the export market, there is a high probability to continue exporting for a substantial period of time, the majority of the firms in our sample stay in the export market for at least two years. The composition of the subsample of 'entrants' is as follows: 'strict' entries constitute about 40 percent of the total number of entries into exports observed for a subsample of entrants; about 50 percent of the entries are by firms that stay in the export market for at least two years after the entry; and only 10 percent of the entries are by those firms that start exporting only for one year and never reenter again. We note that the results we report in the article are similar to the ones we get if, in defining our treatment group, we use only 'strict entrants' (as defined earlier), not the whole group of entrants.

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Table 2. Differences in means in innovation propensity for the group of entrant firms before and after entering exports

	Large firms		Small and medium firms	
	Two years before-year of entry	Two years before-two years after	Two years before-year of entry	Two years before-two years after
	Difference in means	Difference in means	Difference in means	Difference in means
Product innovation dummy	0.08	0.20***	0.05**	0.02
Process innovation dummy	0.15**	0.16**	0.07***	0.03

*, **, ***, and † are significantly different from zero at the 10%, 5%, 1%, and 0.1% level, respectively.

for at least one year, are excluded from the analysis. Since in our study we are interested in estimating the 'average effect of the treatment on the treated,' we focus on entrants: these are the firms that are subject to the treatment. This last subsample is of particular importance if we want to assess the effect of export on innovation: we can trace the changes in innovation behavior that are associated with the change in export status, as we observe the firms before and after the export decision.

Table 1 shows that exporters invest more intensively in R&D and innovate more often than non-exporters, both in process and product. Columns 3 and 6 present the descriptives for the entrants. These firms display figures lying between those of exporters and non-exporters. This is to be expected since these firms are in transition between the exporting and non-exporting groups.

We proceed by comparing the innovation status of a firm for the subsample of entrants before and after the entry into exports took place. Table 2 presents the results of the t-test for the two time windows: (1) two years before entry-year of entry; and (2) two years before entry-two years after entry. Overall, we observe an increase in innovation output, for both product and process innovation. For SMEs, exporting is associated with significant increases in product as well as process innovation propensity at the year of entry in foreign markets. In the case of large firms, the significant increase is observed only for process innovation. For the time window two years before-two years after entry, however, the increase in innovation frequency is not statistically significant for SMEs. For large firms, the difference between pre-entry and post-entry innovation frequency continues to be significant.

In Tables 3a and 3b, we report the results for the matching estimations. Table 3a presents the results of the analysis for the group of large firms. We observe a significant difference in process innovation frequency between matched new exporters and non-exporting firms ($p < 0.01$). Entrants are more likely to produce a process innovation as compared to non-exporters starting the year of entry, with the effect continuing the following two to three years. Moreover, the results show no significant difference in product innovation frequency compared to non-exporters.

Table 3a. Large firms: differences in innovation output between exporting and non-exporting firms by years before/after entry into exports (matching estimator)

	Three years before	Two years before	One year before	Year of entry	One year after	Two years after	Three years after
Product innovation	**0.16****	0.00	0.02	−0.00	−0.01	0.02	0.10
	(0.07)	(0.06)	(0.06)	(0.05)	(0.06)	(0.07)	(0.08)
Process innovation	0.03	0.03	0.06	**0.16****	**0.20*****	**0.28†**	**0.17****

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	(0.10)	(0.08)	(0.06)	**(0.06)**	**(0.07)**	**(0.07)**	**(0.08)**
N of obs	268	287	329	334	321	314	295

, *, and † are significantly different from zero at the 5%, 1%, and 0.1% level, respectively.

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Table 3b. SMEs: differences in innovation output between exporting and non-exporting firms by years before/after entry into exports (matching estimator)

	Three years before	Two years before	One year before	Year of entry	One year after	Two years after	Three years after
Product innovation	**0.04****	0.02	**0.05*****	**0.08**†	0.03	**0.06*****	0.02
	(0.02)	(0.02)	**(0.01)**	**(0.01)**	(0.02)	**(0.02)**	(0.02)
Process innovation	−0.00	−0.00	0.03	**0.05*****	0.04	0.04	0.01
	(0.02)	(0.02)	(0.02)	**(0.02)**	(0.02)	(0.02)	(0.02)
N of obs	6,772	6,883	7,043	7,066	6,966	6,905	6,762

, *, and † are significantly different from zero at the 5%, 1%, and 0.1% level, respectively.

Table 3b presents the outcome from the matching procedure in the sample of SMEs.[8] We observe a significant difference in product innovation status already one year before entering the export market, with the most pronounced effect at the year of entry. With respect to process innovation frequency, there is a significant difference in process innovation between non-exporters and new entrants at the year of entry into exports and only a marginally significant small increase in process innovation frequency in the two following years.

Overall, these results are in line with the hypothesized difference in the effect of exports on product/process innovation depending on firm's size.[9]

choose a fairly small number. In simulations in Abadie and Imbens (2002) using four matches was found to perform well in terms of mean-squared error.' Thus, for the robustness check,

[8] The matching estimator relies on the assumption that selection into treatment occurs solely on the basis of factors observed by the researcher. This might appear as a strong assumption. Yet matching still constitutes a useful starting point. Past research in the program evaluation literature has shown that techniques that assume selection on observables perform well (in the sense of replicating an experimental benchmark) when: (1) researchers use a rich list of covariates to model the probability of treatment; (2) units are drawn from similar markets; and (3) outcomes are measured in the same way for both treatment and control groups (e.g., Azoulay *et al*., 2011; Dehejia and Wahba, 2002). These conditions generally hold in this study. Moreover, an assumption is made on the joint distribution of treatments and covariates, specifically: $0 < \text{probability}\ (T = 1 \mid X) < 1$. In other words, the probability of assignment to treatment is bounded away from zero and one. This assumption is necessary for having matched nontreated subjects for each treated entity. In our sample, box plots inspection (not reported here, but available upon request) show that the exporting and the control samples substantially overlap across relevant variables.

[9] We also did some robustness checks with respect to the matching estimator. First, we used an alternative definition of the 'distance' for the nearest-neighbor estimator implemented by Abadie *et al*. (2001); more specifically, we used the Mahalanobis metrics. Second, we used a different number of control units to match the treated observations. Abadie *et al*. (2001:14) indicate that: 'In practice one should typically

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As a parametric alternative to the matching technique, we estimate the regression that models the choice of a firm to do product or process innovation relating it to the prior export status. Tables 4a–b report the results of the random effects linear model with AR(1) disturbance for large and small firms respectively.[10,11] Models 2 and 4 use the predicted probabilities of being an exporter from the first-stage random effects linear regression in place of the export variables. The results of the first-stage export regression are reported in Table 5.

Overall, the results are consistent with the matching estimation. We confirm the absence of a relationship between exporting and product innovation for large firms (Table 4a, Model 1). Furthermore, export status of a firm at time t − 1 is positively and significantly associated with the process innovation decision (Table 4a, Model 3). For the subsample of SMEs, we find a positive association between product innovation and the export status of a firm (Table 4b, Model 1). These results are broadly confirmed in the instrumented models (Columns 2 and 4

we varied the number of control units and performed the analysis for one, two, and three matches. The results of the robustness check are in line with the main results. They are not reported in the article for the sake of conciseness, but are available upon request.

[10] The total number of observations in the panel (both large and small firms) equals 23,226. The omitted subsample is exiters, so the total number of observations in Table 1 is (23,226 minus number of exiters). The total number of observations with lagged variables (at time t − 1) is reduced to 19,737. In the first-stage linear probability model, the export decision is estimated on the 5,056 and 14,681 observations for large and small firms, respectively (Table 5), which gives a total of 19,737 firm-year observations. The number of observations is again reduced in Tables 4a–4b because the export variable is lagged one and two years.

[11] We also estimated a random effects probit and results are virtually the same; they are available from the authors upon request.

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Table 4a. Random effects linear model with an AR(1) disturbance (large firms)

	Product innovation		Process innovation	
	Model 1	Model 2 Predicted probabilities of export	Model 3	Model 4 Predicted probabilities of export
Export(t − 1)	0.07 (0.04)	0.26 (0.23)	0.08* (0.04)	0.43* (0.24)
Export (t − 2)	0.03 (0.04)	0.14 (0.23)	−0.01 (0.04)	−0.10 (0.24)
R&D intensity (t − 1)	0.55 (0.41)	0.52 (0.41)	0.62 (0.42)	0.62 (0.42)
R&D dummy (t − 1)	0.11† (0.02)	0.11† (0.02)	0.12† (0.02)	0.12† (0.02)
Advertising intensity (t − 1)	0.008*** (0.003)	0.008*** (0.003)	0.00 (0.00)	0.00 (0.00)
Size (ln of N of employees)	0.05*** (0.01)	0.04*** (0.01)	0.07† (0.01)	0.06† (0.01)
Foreign capital dummy	−0.02 (0.02)	−0.03 (0.02)	0.02 (0.02)	0.01 (0.02)
Growing market	0.004 (0.01)	0.004 (0.01)	−0.00 (0.01)	−0.00 (0.01)
Hi-tech industry dummy	0.08** (0.03)	0.05* (0.03)	0.01 (0.03)	0.00 (0.03)
Intercept	−0.15 (0.10)	−0.39*** (0.15)	−0.19* (0.10)	−0.95*** (0.29)
Year dummies	Included	Included	Included	Included
N of observations	3,149	3,149	3,149	3,149

*, **, ***, and † are significantly different from zero at the 10%, 5%, 1%, and 0.1% level, respectively.

of Tables 4a and 4b). For the process innovation decision, we find a significant relationship between exports and process innovation for SMEs at time t − 2 (Table 4b, Model 3), an effect that disappears when instrumenting exports, in line with the matching results.

The results broadly support both Hypothesis 1 and Hypothesis 2, showing that large firms are more prone to process innovation once they start exporting, while SMEs' entry into export markets is accompanied by product innovation.

ADDITIONAL ANALYSES

We proceeded by conducting some additional analyses to provide further evidence consistent with our hypotheses and the mechanisms behind the

Table 4b. Random effects linear model with an AR(1) disturbance (small firms)

	Product innovation		Process innovation	
	Model 1	Model 2 Predicted probabilities of export	Model 3	Model 4 Predicted probabilities of export
Export(t − 1)	0.035*** (0.01)	0.08 (0.05)	−0.00 (0.01)	0.03 (0.06)
Export (t − 2)	0.03** (0.01)	0.11** (0.05)	0.02* (0.01)	−0.06 (0.06)
R&D intensity (t − 1)	0.75*** (0.23)	0.75*** (0.23)	0.54* (0.27)	0.55** (0.27)
R&D dummy (t − 1)	0.10† (0.01)	0.10† (0.01)	0.07† (0.01)	0.07† (0.01)
Advertising intensity (t − 1)	0.01† (0.002)	0.01† (0.002)	0.000 (0.002)	0.001 (0.002)
Size (ln of N of employees)	0.02† (0.006)	0.01*** (0.006)	0.07† (0.007)	0.08† (0.008)
Foreign capital dummy	−0.04** (0.01)	−0.05*** (0.01)	−0.01 (0.02)	−0.006 (0.02)
Growing market	0.02† (0.008)	0.02† (0.008)	0.08† (0.009)	0.08† (0.009)
Hi-tech industry dummy	0.06† (0.01)	0.04*** (0.01)	−0.004 (0.01)	−0.000 (0.01)

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Intercept	−0.02 (0.02)	−0.02 (0.02)	−0.09† (0.02)	−0.10† (0.02)
Year dummies	Included	Included	Included	Included
N of observations	9,925	9,925	9,925	9,925

*, **, ***, and † are significantly different from zero at the 10%, 5%, 1%, and 0.1% level, respectively.

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Table 5. Random effects linear regression (first stage)

	Large firms Export (t)	Small firms Export (t)
Exchange rate index	0.14† (0.02)	0.28† (0.02)
R&D intensity (t − 1)	0.02 (0.13)	0.43*** (0.15)
Advertising intensity (t − 1)	0.002 (0.001)	0.002* (0.001)
Size (t − 1) (ln of N of employees)	0.01** (0.008)	0.12† (0.005)
Import (t − 1)	0.11† (0.01)	0.15† (0.007)
% of foreign capital	0.02** (0.01)	0.07† (0.01)
Intercept	0.52† (0.13)	−0.18** (0.08)
Industry and location dummies	yes	yes
N of observations	5,056	14,681

*, **, ***, and † are significantly different from zero at the 10%, 5%, 1%, and 0.1% level, respectively.

suggested relationships. To begin, according to the proposed mechanism that explains why large firms experience an increased incentive to produce process innovations when they enter export markets, investments to decrease marginal costs and increase productivity (i.e., process innovations), and investments in export activities are complementary. Assuming investing in process R&D entails a fixed cost, by spreading the costs of their process R&D over a larger level of output, larger firms can appropriate more value from process innovations than can small firms. And if large firms are relatively more inclined toward process innovation, since entering into foreign markets through export they are able to further enlarge their market size, they will experience an even larger incentive to invest in this innovation type. This argument, as exposed by Lileeva and Trefler (2010) and Haidar (2012), implies an additional result. Firms that enter export markets tend to have higher productivity that those that do not enter, and they have lower productivity than those that are already in the export market: that is why they need to invest in productivity to sustain their growth in export markets (e.g., Bernard and Jensen, 1999). Yet within the group of first-time exporters, those who will invest more in process innovations are precisely those firms that need it, i.e., firms with relatively low productivity. By the same token, for lower- productivity firms, incurring the fixed costs of inno- vation investments is justifiable only if accompanied by the larger sales volumes that come with exporting.

Thus, we investigated whether our data support this prediction. Our measure of productivity is the logarithm of labor productivity calculated as the

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ratio of total sales to the number of employees. Firms were classified into a group of firms with 'high productivity' if their labor productivity was higher than what their industry and size would predict and into a group of firms with 'low productivity' if their labor productivity was lower.[12] Indeed, the matching analysis (results reported in Table 6) shows that firms in the 'low productivity' group are the ones that demonstrate a greater propensity to introduce process innovations around entry into exports and in the following two years. Conversely, firms with higher productivity show no specific positive result associated with the entry into exports.

Second, we predicted that SMEs that enter export markets will produce more product innovations. It is so, we posited, because when exporting, young firms need to adapt their product to the new markets, and they typically need to do so more than exporting large firms (e.g., Cooper and Kleinschmidt, 1985). We, therefore, investigated if an increase in small firms' product innovations is related to their need to adapt to novel foreign markets.

We did so in two ways. First, we analyzed the type of innovations produced in the aftermath of the entry of SMEs into export markets. To this end, we exploit a specificity of our dataset: the ESEE data provide the information on what characterizes the product innovation each firm brings to the market. In particular, firms are asked whether the product innovations they produce include: (1) new materials; (2) new

[12] Specifically, we estimated the regression that related productivity to firm size, foreign capital ownership, and industry. Using the residuals, we classified firms into high and low productivity groups.

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Table 6. Large firms: differences in process innovation frequencies between exporting and non-exporting firms by years before/after entry into exports (matching estimator)

		Three years before	Two years before	One year before	Year of entry	One year after	Two years after	Three years after
Productivity higher than median	Process innovation	−0.04 (0.35)	0.12 (0.15)	0.14 (0.12)	0.09 (0.11)	0.03 (0.10)	−0.31 (0.18)	**−1.06** (0.47)
	N of obs	68	74	93	104	104	109	98
Productivity lower than median	Process innovation	0.07 (0.10)	0.11 (0.09)	**0.16** (0.07)	**0.32**† (0.07)	**0.34**† (0.09)	**0.42**† (0.09)	0.23 (0.11)
	N of obs	200	213	236	230	217	205	197

, *, and † are significantly different from zero at the 5%, 1%, and 0.1% level, respectively.

components or intermediate products; (3) new design and presentation; and/or (4) new functions. It is possible to argue that a 'product adaptation' strategy will be associated with an increase in the intensity of pursuing different types of product innovation. That is, with the entry into exports, firms may for example, start changing the design and presentation or they may incorporate new materials or components to meet the requirements coming from foreign markets.

To investigate the link between exports and these different product innovation features, we followed the same steps as in our previous empirical analyses. We compared the types of product innovation the firms in the subsamples of entrant firms produce to those of non-exporters using a matching estimator. As matching covariates, we used the same variables as in the previous analysis: R&D intensity, import status of a firm, size, foreign capital dummy, growing market dummy, and industry and location dummies. We also include the variable that measures the number of product innovations a firm has introduced in a given year. Table 7 reports the results of the estimation. We observe that SMEs start changing the design and presentation of their products already one year before exporting compared to similar non-exporters, and they continue doing so for some years after they started exporting. Overall, we can speculate that the results of this analysis could indicate that SMEs tend to invest in product adaptation preparing for exports and that this strategy continues after they entered the export market. Such a pattern might be particularly consistent with learning about foreign markets and adapting to these new requirements.

Next, guided by the international marketing literature, we also investigated the propensity of SMEs to adapt their products to foreign markets. We did so by examining some of the factors that would predict a higher or lower propensity of adapting. In essence,

Table 7. SMEs: differences in the type of product innovation between exporting and non-exporting firms by years before/after entry into exports (matching estimator)

	Three years before	Two years before	One year before	Year of entry	One year after	Two years after	Three years after
New materials	**0.03** (0.01)	0.01 (0.01)	0.01 (0.01)	**0.03** (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
New components or intermediate products	0.01 (0.01)	−0.00 (0.01)	0.02 (0.01)	**0.03**** (0.01)	0.01 (0.01)	0.01 (0.01)	−0.01 (0.02)
New design and presentation	**0.04** (0.02)	0.01 (0.01)	**0.04**** (0.01)	**0.07**† (0.01)	**0.04** (0.01)	**0.04** (0.02)	0.02 (0.02)
New functions	0.00	0.00	0.00	0.00	−0.01	0.00	−0.01

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	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N of obs	5,973	6,063	6,220	6,304	6,204	6,137	6,003

, *, and † are significantly different from zero at the 5%, 1%, and 0.1%, level respectively.

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Table 8a. Market-oriented SMEs: differences in the propensity and type of product innovation between exporting and non-exporting firms by years before/after entry into exports (matching estimator)

Market-oriented firms	Three years before	Two years before	One year before	Year of entry	One year after	Two years after	Three years after
Product innovation	0.07	0.05	**0.07****	**0.12**†	0.06	0.03	−0.05
	(0.04)	(0.04)	**(0.03)**	**(0.02)**	(0.03)	(0.03)	(0.04)
New materials	0.03	0.04	0.03	**0.06*****	**0.08*****	**0.05****	−0.00
	(0.03)	(0.02)	(0.01)	**(0.02)**	**(0.02)**	**(0.02)**	(0.02)
New components or intermediate products	0.02	0.01	**0.04****	**0.06*****	**0.07*****	**0.06*****	−0.00
	(0.02)	(0.02)	**(0.02)**	**(0.02)**	**(0.02)**	**(0.02)**	(0.02)
New design and presentation	0.08	0.04	**0.09*****	**0.11**†	**0.14**†	0.05	0.00
	(0.04)	(0.03)	**(0.02)**	**(0.02)**	**(0.03)**	(0.03)	(0.04)
New functions	**0.06****	0.04	−0.01	0.03	0.01	0.01	−0.00
	(0.03)	(0.02)	(0.01)	(0.01)	(0.02)	(0.02)	(0.03)
N of obs	1,865	1,897	1,963	1,996	1,936	1,921	1,867

, *, and † are significantly different from zero at the 5%, 1%, and 0.1% level, respectively.

we verified if in our sample SMEs that are *ex ante* and, according to theory, most likely to adapt when beginning to export are also the firms that display a higher propensity to produce product innovations in the aftermath of the export decision. Cavusgil *et al*. (1993), among others, discuss how product adaptation is *not* generally pursued by high-tech firms. Thus, it is hypothesized that technology orientation is negatively related to the various aspects of product and promotion adaptation: global strategies are more suitable in technology-intensive industries, as products are more universal. At the same time, firms that are characterized by higher marketing and advertising capabilities (i.e., more 'market oriented') are expected to adapt more to foreign markets conditions (Calantone *et al*., 2004).

Our theory would predict that 'market-oriented' firms exhibit a higher propensity to innovate in relationship with the export decision and, specifically, show higher intensity in adapting their product to foreign markets requirements. Firms were defined as market oriented if they had a ratio of advertising expenditures to sales higher than predicted by their industry and size and as nonmarket oriented if the ratio was lower.[13] Tables 8a–b confirm this hypothesis, showing that market-oriented firms increase the

[13] In other words, similarly to the productivity measure we described before, we defined market orientation—i.e., more market-oriented versus less market-oriented firms—based on the regression that relates firm advertising intensity to its size, foreign capital ownership, and sector.

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frequency of innovating compared to similar non-exporters and, in particular, of innovating in design and presentation of their products one year before they enter the export market. We also observe a significant increase in new component and new material innovations; however, it is less pronounced. On the contrary, in the subsample of nonmarket-oriented firms, we do not see such a clear pattern. There is an increase in the frequency of innovating in product one year before and in the year of entry into exports, however, we do not observe significant difference in the types of product innovation pursued between nonmarket-oriented exporters and non-exporters in the after entry period.

Our theory would also predict that high-tech firms are not necessarily increasing their innovation activity as a consequence of their export activities since they have a lower need to adapt their products. To test this prediction, with a matching estimator we compared the innovation outcome of high-tech SMEs that began to export to similar high-tech SMEs that never entered export markets during the sample period. We define technology orientation analogously to market orientation: firms are defined as technology oriented if the ratio of R&D expenditures to total sales is higher than predicted by their size and industry. Results of the estimation reported in Table 9 show that, consistent with our expecta- tions, there is no significant difference between exporting and non-exporting technology-oriented firms in their propensity to innovate after these firms enter the export market; nor do these firms differ

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Table 8b. Non-market-oriented SMEs: differences in the propensity and type of product innovation between exporting and non-exporting firms by years before/after entry into exports (matching estimator)

Non-market-oriented firms	Three years before	Two years before	One year before	Year of entry	One year after	Two years after	Three years after
Product innovation	0.00	0.03	**0.06*** **	**0.07*** **	0.01	0.03	0.04
	(0.03)	(0.02)	**(0.02)**	**(0.02)**	(0.02)	(0.03)	(0.02)
New materials	−0.00	0.02	**0.03** **	0.01	−0.02	−0.02	0.02
	(0.00)	(0.01)	**(0.01)**	(0.01)	(0.01)	(0.02)	(0.02)
New components or intermediate products	0.00	0.00	0.02	0.00	−0.02	−0.01	−0.00
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
New design and presentation	0.02	0.00	**0.04** **	**0.06*** **	−0.00	0.00	0.03
	(0.02)	(0.02)	**(0.02)**	**(0.02)**	(0.02)	(0.03)	(0.02)
New functions	−0.02	0.01	0.00	0.00	−0.01	−0.03	−0.01
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
N of obs	4,070	4,128	4,221	4,268	4,232	4,181	4,102

, *, and † are significantly different from zero at the 5%, 1%, and 0.1% level, respectively.

Table 9. Technology oriented SMEs: differences in the propensity and type of product innovation between exporting and non-exporting firms by years before/after entry into exports (matching estimator)

Technology-oriented firms	Three years before	Two years before	One year before	Year of entry	One year after	Two years after	Three years after
Product innovation	0.05	−0.05	0.08	**0.13*** **	0.06	−0.00	−0.01
	(0.05)	(0.05)	(0.04)	**(0.04)**	(0.05)	(0.04)	(0.07)
New materials	0.05	−0.03	0.04	0.04	0.06	0.03	0.02
	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)
New components or intermediate products	0.00	−0.05	−0.01	**0.08** **	0.07	0.01	0.05
	(0.03)	(0.03)	(0.03)	**(0.03)**	(0.04)	(0.04)	(0.05)
New design and presentation	0.06	−0.07	0.01	**0.09** **	0.05	−0.01	−0.05
	(0.04)	(0.04)	(0.04)	**(0.04)**	(0.04)	(0.04)	(0.06)
New functions	−0.01	**−0.09** **	−0.01	0.00	0.01	**−0.07** **	−0.14
	(0.04)	**(0.03)**	(0.03)	(0.03)	(0.04)	**(0.03)**	(0.06)
N of obs	1,679	1,679	1,713	1,725	1,699	1,686	1,651

, *, and † are significantly different from zero at the 5%, 1%, and 0.1% level, respectively.

from similar non-exporters in terms of the types of product innovation they pursue. That is, export does not induce high-tech firms to innovate more.

CONCLUDING REMARKS

We have examined the effect of export on firms' innovation output in search of novel empirical evidence on the learning-by-exporting phenomenon. Our results indicate that exporting status is positively associated with firm innovation output. This positive association persists after controlling for

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other factors that may affect the decision of a firm to innovate and after attempting to correct for endogeneity in the exports-innovation relationship. The results confirm the hypothesized differences in the effect of exports on innovation, depending on firm size, with some important distinctions. Large firms show increased process innovation output after the entry into export markets, with the effect being most pronounced two years after the entry. Small and medium firms, conversely, start product innovation before they enter the export market, with the effect of exporting lasting for about two years after the entry.

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Our results, therefore, suggest that large, experienced firms accompany the entry into exports by investing in process innovation, whereas SMEs have a tendency to pursue product innovation *for* export markets. Moreover, while the persistent superior performance in product innovation of exporting SMEs compared to similar non-exporters—even after they entered foreign markets—evokes the idea there is some learning associated with exports, the change in the types of product innovation exporting SMEs produce suggests this might be more properly characterized as 'learning about export markets' rather than as 'learning about new technologies,' as prior literature has often implied.

Additional analyses provide evidence consistent with these findings. SMEs that according to extant literature are *ex ante* more likely to adapt their products to foreign markets exhibit a higher propensity to increase the intensity of product adaptation activities, while firms that are more technology oriented do not. At the same time, large firms pursue process innovations to increase their productivity and this is particularly true for entrants that are *ex ante* relatively less productive.

Contribution to the literature

Overall, our results are consistent with the hypotheses of this study and provide several contributions to the literature. First, our findings strengthen the idea that export and innovation decisions are interrelated. After controlling for endogeneity, exporting firms show a different innovation pattern as compared to non-exporting firms mostly around the year they enter foreign markets, and this effect might start one year before and lasts about two years after the entry. If it is true that foreign markets might provide firms with novel information that, in turn, can promote learning, it is also true that firms tap into this knowledge and invest in innovation according to their specific needs, related to their exporting strategy. Complementing prior literature, we stressed the important role of firms' agency in the learning-by-exporting process.

Second, we have confirmed that product and process innovations are pursued by different firms given their different needs and incentives. While the distinction between product and process innovation preferences has been previously stressed in the industry dynamics literature (e.g., Cohen and Klepper, 1996) and also has been applied to understand firms' propensity to start exporting (e.g.,

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Becker and Egger, 2013; Van Beveren and Vandenbussche, 2010), this study is among the first ones to examine the different effects exports might have on these two types of innovation. Furthermore, while prior studies (e.g., Salomon and Shaver, 2005a) have documented a possible effect of exports on firms' innovation outcome, we have shown that entering export markets has a different effect on different dimensions of technological performance for different firms. And these different effects are not merely the outcome of knowledge spillovers, but also of purposeful decisions firms make when entering export markets. Hence, our findings contribute to a better understanding of the complex relationship between innovation and exports.

Limitations

There are several limitations of this article that deserve to be acknowledged. First, given that the innovation output does not measure learning directly, one can only suppose that the observed pat- terns are indeed the result of learning-by-exporting. A more direct measure of learning (perhaps through the use of primary data) would be used to provide additional evidence on the learning-by-exporting hypothesis. Unfortunately, we do not have this infor- mation. Yet, we were at least able to trace the novel content of the innovations produced in the aftermath of exporting decisions, thus providing some evi- dence on the content of what might be learned abroad, if not on the process through which this learning takes place. Second, in this study we observed innovation output for a limited post-entry period. This choice certainly minimizes possible confounding effects. However, the full effects of exports may sometimes be appreciated only a number of years after entering foreign markets, espe- cially in the case of small and medium firms. Tem- poral issues and the difference in the patterns of learning between large and small enterprises might, therefore, deserve more attention and can constitute a fruitful avenue for future research. Third, although we did our best to account for the endogeneity of the export decision, we should acknowledge that we cannot claim causality in the empirical results, as we were not able to exploit any exogenous shock. Fourth, we used firm size as an example of firm heterogeneity to help us support the idea of 'purposive' learning from export markets. It is also true that other dimensions of firm heterogeneity can be relevant for explaining the differences in

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learning-by-exporting patterns across firms. We have introduced several other firm characteristics that could matter for the export-innovation link, such as market orientation, technological orientation, and productivity levels, and provided theoretical arguments on why these characteristics might matter. There are, however, other dimensions that could be equally important. For instance, one of the directions to pursue to further develop the idea that firm heterogeneity matters for the export-innovation relationship is to look at the innovation history of firms. Firms' prior history of innovation (product or process) before exporting is likely to affect their innovation behavior after these firms enter the export market. That is, although large firms may be more prone to pursue process innovation while entering exports, it may not be true for large firms that were more product innovation intensive before entry. We leave these issues to future research. Moreover, ideally we should be able to build a *process* model of the relationship between innovation and exports throughout the life of firms.[14] In this article, we considered just a 'snapshot' of firms in a specific moment in time—their entry into export markets. Yet, we hope this study might constitute a first step in the direction of such a model. Last but not least, we should acknowledge that while our empirical analysis is predicated on the moderating role of organizational size, an alternative interpretation of our results is that it is not size *per se* that moderates the effect of exporting on innovation, but rather an unobserved factor that correlates with size.

Implications

Notwithstanding the limitations of our study, our findings provide some implications that are relevant from both an innovation management and a public policy perspective. Innovation is becoming a critical factor in attaining competitive advantage, with technological performance being more and more related to firm economic and commercial success. Hence, a better understanding of the variables that can enhance a firm's innovation output—and this article provided evidence on exports being one of such variables—is of increasing importance. More generally, managers are advised not to underestimate the potential interdependencies between innovation and

[14] We thank two anonymous referees for suggesting these lines of research.

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export decisions and the necessary fit between these and other firm characteristics. The notion that the activities of a firm's strategy and their effects on performance are not independent is a key notion in strategy (e.g., Levinthal, 1997; Porter, 1996) and is often forgotten. In addition, a better comprehension of the drivers of innovation is crucial not only for managers but also for policy makers. Understanding for which firms and to what extent exports may foster innovation activity and, as a consequence, improve overall firm performance is important for designing public policies aimed at promotion of innovation and growth. Specifically, if innovation and export decision are interrelated, suitable policies should take this into consideration. For instance, trade liberalization might foster SMEs product innovation efforts and, at the same time, policies aimed at nurturing SMEs' product innovations might reinforce their presence in foreign markets.

CONCLUSION

In sum, this article sheds some new light on the complex relationship between innovation and exports. Future research can build on these ideas and results and study in greater depth the factors and mechanisms that facilitate learning from export markets and their impact in helping firms innovate more and more efficiently.

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APPENDIX
Variable definitions

Variable	Description
Export	Dummy variable equal to 1 if the firm exports at time t
Import	Dummy variable equal to 1 if the firm imports at time t
R&D	Dummy variable equal to 1 if the firm reported R&D expenditures at time t
R&D intensity	Share of R&D expenditures over total sales at time t
Size (ln of sales)	Firm size measured as the logarithm of total sales at time t
Size (ln of number of employees)	Firm size measured as the logarithm of the total number of employees at time t

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Foreign capital	Dummy variable equal to 1 if the firm has more than 50 percent of foreign capital at time t
Product innovation	Dummy variable equal to 1 if the firm realized product innovation at time t
Process innovation	Dummy variable equal to 1 if the firm realized process innovation at time t
Growing market	Dummy variable equal 1 if the market evolution with respect to the previous year was perceived as expansive by the firm

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Definition of product and process innovation in the ESEE survey

Product innovation:

— whether a firm obtained new products or products with new features that are different from those that a firm produced in the previous years. If the answer is 'yes,' the type of modification is asked:
  — incorporates new materials
  — incorporates new components or intermediate products
  — incorporates new design or presentation
  — performs new functions

Process innovation:

— whether a firm introduced an important modification in the production process. If the answer is 'yes,' the type of modification is asked:
  — introduction of new machinery
  — introduction of new methods of production organization
  — both

Industry breakdown, 1990

Industry	Number of firms
Meat products	62
Food and tobacco	231
Beverages	53
Textiles	251
Leather and footwear	70
Wood and wood products	60
Paper	60
Publishing and printing	109
Chemical products	150
Plastic and rubber products	95
Nonmetal mineral products	160
Metallurgy	60
Metallic products	172
Machinery and equipment	161
Office machinery and computing	41
Electronics and electronic equipment	159
Autos and motor vehicles industry	76
Other transport equipment	51
Furniture	108
Miscellaneous manufacturing	59
Total	2,188

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