Papers in Innovation Studies

Paper no. 2015/17

Export-led innovation: the role of export destinations

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This is a pre-print version of a paper that has been submitted for publication to a journal.

This version: April 2015

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JEL codes: F10, O33, P51

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[1] The author would like to thank for discussion and suggestions Davide Castellani, Marcello Messori and Cristiano Antonelli. The paper has benefited from comments received during the following seminars and conference presentations: Explaining Economic Change Workshop, Rome, November 2014; seminar at CIRCLE, University of Lund, March 2015.The author has benefitted from the access to the EU-EFIGE/Bruegel-UniCredit database, managed by Bruegel and funded by the European Union's Seventh Framework Programme ([FP7/2007-2013] under grant agreement num. 225551), as well as by UniCredit. The author is also grateful to Bruegel for the access to the quasi full set EFIGE database at their premises.
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1. Introduction

This paper analyzes the effect of exporting activity on the innovative performances of European firms. While there is a general consensus on the fact that firms that are able to innovate are more likely to access international markets and export (Roper and Love, 2002; Melitz, 2003), an increasing attention is now paid to investigate the effect of being an exporter on innovative outcomes. The intuition is that by operating on international markets firms are induced to implement new organizational and technological routines that eventually allow them to increase productivity levels. A growing literature has analyzed the causal link existing between exporting activity and innovation (Liu and Buck, 2007; Andersson and Lööf, 2009; Lileeva and Trefler, 2010; Bustos, 2011, Lööf et al, 2015), finding, in most of the cases, that exporting activity indeed increases the probability to introduce innovations at the firm level.

However in this literature little has been said about the specific mechanisms that drive the causal effect of exports on innovation: why and how does exporting increases the probability to introduce new products and adopt new technologies? Moreover the literature is also not unanimous about which types of innovation outputs are more affected by exporting activity: positive effects have been found in different empirical studies on, respectively, product innovation (Bratti and Felice, 2012), process innovation (Damijan et al., 2010) or patent applications (Salomon and Shaver, 2005).

In this paper I analyze two differentiated mechanisms through which exporting might affect the decision to introduce innovations. On the one hand exporting activity can foster innovation because firms learn to innovate from foreign clients and competitors when they are active in very technologically-advanced foreign markets: I call this the technological learning effect. On the other hand exporting activity can induce firms to innovate because foreign markets can increase substantially the demand for the firms' output and hence the profitability of introducing new technologies: I call this the foreign demand effect. Of course in many cases both effects are at stake and jointly influence the innovative strategies of firms, however it seems important to identify the direct effect of each of them separately.

The advantage of this approach is that exporting is no longer considered to have a homogenous effect on innovation, on the contrary every foreign market can be considered as a combination of these two inducement effects on innovation. The first contribution of this paper therefore consists in introducing the role of the destination of exports in the analysis of the effect of exports on innovation. Some export destinations might induce innovations because they provide relevant spillovers for exporting firms, i.e. through the technological learning effect, while other destinations might induce innovations because of the high growth of their demand, i.e. through the foreign demand effect.

The second contribution of the paper relies on the fact that the positive effect of exporting activity is not assessed on a generic measure of innovation: each of the two effects introduced is supposed to have differentiated effects on different types of innovation strategies. The main benefit of the technological learning effect is to decrease the relevant research costs related with the introduction of brand new innovations, since the spillovers from foreign customers and competitors allow easier access to specific knowledge and competences. Therefore exporting in very technologically advanced markets should induce firms to introduce brand new product innovations, close to the technological frontier, as suggested by the findings of the literature on interactions with international clients

(Laursen, 2011; Bratti and Felice 2012b; Fitjar and Rodriguez-Pose, 2012; Harirchi and Chaminade, 2014). On the contrary the main contribution of the foreign demand effect is to increase the potential number of units sold by firms: therefore exporting in markets with a high growth of demand is likely to induce firms to adopt machineries and technologies that allow to increase the scale and efficiency of their production (Desmet and Parente, 2010), to cope with the increased size of their final market.

In the paper I test the relevance of the technological learning and demand effect of exporting activity taking advantage of the EU-EFIGE/Bruegel-UniCredit dataset (European Firms in a Global Economy), which includes detailed firm-level information about export activity and innovation performances of a large number of firms active in the five largest European economies (Germany, France, Italy, Spain and United Kingdom) in the period 2007-2009. The main advantage of the dataset is that it includes information on the three most important export destinations of exporting firms. I combine this information with external data on the intensity of expenditures in Research and Development (R&D) in the countries of export destination (in the same sector of the exporting firm), and the growth of imports of the markets in which firms are exporting (again in the same sector of the exporting firm). I consider the foreign intensity of R&D as a good proxy of the level of technological development and hence of the technological learning effect, while I use the growth of imports in the destination countries as a proxy of the foreign demand effect. I create two indices for each exporting firm which measure the sectoral level of R&D of their export destinations as well as the average sectoral import growth. I include these two indices in a linear probability model that explains the introduction of different innovation strategies for both exporters and non exporters: respectively efficiency strategies and brand new product innovation strategies. The empirical specification addresses the endogeneity issue related with the problems of selection into exporting activity and with the fact that firms can strategically choose the locations of their exports precisely because they want to benefit from a high demand growth or by technological spillovers. Building on the previous literature I devise an instrumental variable strategy that takes advantage of the sectoral propensity at the national level to export to specific countries.

The results of the empirical analysis show that the positive effect of export activity on innovation can be explained by the working of the technological learning and foreign demand effects. More specifically these two effects induce different economic rationales for the introduction of innovation strategies. The technological learning effect increases the probability to introduce brand new product innovations because it decreases the relevant research costs related with the introduction of such innovations. On the contrary the foreign demand effect, by increasing the potential number of units sold, increases the incentives to adopt efficiency strategies based on process innovations since these strategies become very profitable when the overall level of output increases.

The results are important for policy implications: while all types of innovation strategies can have a positive impact on firms' performances, in advanced economies research-based product innovations –which are able to actually shift the world technological frontier- are those with the highest economic impact (Acemoglu, Aghion, Zilibotti, 2006) and also at the firm-level they are likely to have a greater effect on total factor productivity growth (Duguet, 2006). The country patterns investigated in the paper show that even after controlling for firms' size and for sectoral affiliation German firms that export have higher levels of the index that measures the technological learning effect and which favors brand new product innovation, especially with respect to countries such as France, Italy and

Spain. These results suggest that among this subset of European countries firms might lack an important incentive to introduce innovations that are able to increase their future innovative capacities and induce catch up processes.

The paper is organized as follow: Section 2 presents the relevant literature and introduces the main hypotheses concerning the role of the technological learning and foreign demand effect on different types of innovation strategies; Section 3 presents the empirical strategy and the data used, Section 4 presents the results, while Section 5 draws some conclusions and implications for policy.

2. The effect of exports on innovation: technological learning and foreign demand effects

In order to analyze the effect of exporting on innovation it is necessary to understand through which mechanisms exporting activity is able to affect firms' innovation strategies. In this paper I will try to classify in two main categories the different explanations that have been advocated in the related literature to motivate the hypothesis of a positive link between exports and innovation. I will define them the technological learning effect and the foreign demand effect respectively.

The technological learning effect has often been labeled in the literature as the learning-by-exporting hypothesis. This hypothesis was first introduced in the literature that studies the behavior of exporting firms in middle-income and emerging countries. Among these firms it is found that exporting to advanced markets increases the overall productivity of firms. De Loecker (2007) finds that Slovenian firms who export are more productive than non-exporters and that this effect is driven by firms who export to high income countries. Also Verhoogen (2008) finds that increased access to foreign markets induces exporting Mexican firms to upgrade their quality in order to satisfy sophisticated markets. Similar findings are provided by Van Biesebroeck (2005) for Sub-Saharan African companies, by Fafchamps et al. (2008) on a sample of Moroccan manufacturing firms and by Liu and Buck (2007) for Chinese companies. According to this hypothesis being active in international value chains allows firms to benefit from technological spillovers. Firms learn to improve and upgrade their technologies thanks to the interactions that occur mainly and on the demand-side, (knowledge spilling from foreign specialized users) and possibly from foreign competitors.

The effect was found to be relevant also among firms in advanced economies, such as western European countries. Salomon and Shaver (2005) have investigated the learning by exporting effect on a sample of Spanish firms and found that indeed exporting has a positive causal effect on innovation. Moreover Salomon and Jin (2008) found that firms that are more technologically advanced are better able to exploit the benefits of exporting. Crespi et al. (2008) were the first who actually tried to use a direct measure of technological spillovers stemming from the demand side, that is, the access to relevant information from foreign buyers. Their results show that the access to this type of knowledge from foreign customers increases the productivity of a firm. Also Bratti and Felice (2012) suggest that the positive effect on product innovation that originates from exporting activities among Italian firms is probably due to increased knowledge of the markets in which firms are exporting.

A corollary to these analyses is represented by Crinò and Epifani (2012) who find that Italian firms with low technological capabilities (as indicated by lower total factor productivity) are more likely to export to low income countries. Serti and Tomasi (2012), in another study on Italian companies, show that firms that export to high income countries outside the European Union have higher levels of labor and total factor productivity. These results introduce the issue of export destinations: exporting is not to be considered as a homogenous type of inducement on innovation and productivity; on the contrary it might be that exporting is correlated with lower productivity when destination markets are low income countries.

A second common explanation of the positive effect of exporting activity on innovation and productivity is related to the role of foreign demand. Demand growth in general has always been considered among the main determinants of innovation (Schmookler, 1966; Mowery and Rosenberg, 1976). Therefore the access to a large or growing foreign market should induce firms to invest in new technologies since the expected profits are likely to increase with the size of the market and the firms' revenues. The main contributions on the role of foreign demand come from the trade literature in which exporting activity is considered as an increase of a firm's output market.

On the theoretical side Desmet and Parente (2010) show that exporting, by increasing the firms' market size, will also increase the willingness of firms to innovate. Lileeva and Trefler (2010) and Bustos (2011) propose similar models in which the decrease of bilateral tariffs induces firms to pay the fixed costs associated with the investments in technology, because of the increased access to a market of a larger size. The two papers exploit a very similar research setting: Lileeva and Trefler (2010) exploit the effect on Canadian firms of a reduction of tariffs with the United States, while Bustos (2011) analyzes Argentinean firms exposed to a tariff-cut with Brazil: in both cases the authors find that the higher the exposition to the tariff-cuts the higher will be the level of innovative investments. Woerter and Rope (2010) in a panel dataset on Swiss and Irish firms find very limited effect of foreign demand among Swiss firms on product innovation and share of new products.

On the basis of the contributions above it becomes clear that the positive effect of exporting activities on innovation might be due to at least two different underlying mechanisms. An exporting firm might be induced to introduce new technologies because it is benefitting from foreign technological spillovers on the demand side which decrease the fixed cost of innovating (the technological learning effect), or it might be induced to upgrade its technology because the increased foreign market size makes it more profitable to increase the efficiency of the production processes (the foreign demand effect). Of course in many cases both effects are at stake and jointly influence the innovative strategies of firms, however it seems important to identify the direct effect of each of them separately. This approach leads to considering export destinations as heterogeneous in terms of the inducement effect that they exert on firms' innovative efforts, since not all export destinations include the same combinations of these two effects. In the next section I will investigate how the two effects can also lead to quite different innovative strategies.

2.1 Hypotheses

In order to understand which type of outcome the technological learning and foreign demand effects will exert on firm's innovation choices, it is necessary to stress the fact that innovation is not a uniform bundle of activities. A potential pitfall of the existing literature on export and innovation is to consider innovation in general as an undifferentiated economic activity. On the contrary different types of innovations serve different rationales and the external conditions in which firms are operating will induce them to adopt different types of innovation strategies accordingly. The technological learning effect allows firms to benefit from foreign knowledge spillovers which decrease the internal research costs necessary to develop new innovations. The demand effect instead increases firms' potential output and the overall number of units sold. In this section I will focus on two types of innovation strategies (efficiency strategies and brand new product innovation strategies) and I will discuss to what extent the technological learning and demand effects of exporting activity induce firms to adopt each of them.

Efficiency strategy. A possible rationale for the introduction of innovations is the increase of the efficiency of the productive processes, that is, the decrease of the cost of inputs given a certain quantity of output. The ideal way to achieve this goal is the introduction of process innovations, which are typically devised to increase the efficiency of production process.[3] Schmookler (1954) showed that the incentives to introduce process innovations increase with the quantity of output produced, since the efficiency gains on each unit produced will be multiplied by a larger number of units. Therefore when firms experience an increase of their market, and therefore of the units produced, they will be induced to adopt process innovations. Scherer (1991), as well as Cohen and Klepper (1996), provide theoretical and empirical evidence that the increase in the number of units sold induces firms to dedicate more research efforts towards process innovations rather than towards product innovation. Their results are confirmed by Reichstein and Salter (2006) who also find that process innovation is a function of the size of firms. As a corollary of these studies Berchicci et al. (2014) find that indeed economic downturns in the sector of activity of a firm mainly affect negatively process innovation strategies, which are more dependent on the general level of sales of firms. Desmet and Parente (2010) investigate the effect of foreign demand on innovation strategies and show that an increase of international sales will foster process innovations. According to this perspective it is likely that the foreign demand effect of exporting activity, by increasing the potential output of exporters, will mainly increase the incentive for firms to improve the efficiency of their productive processes.

Hypothesis 1: The foreign demand effect of export activity will mainly increase the incentives for firms to implement efficiency strategies.

Brand new product innovation strategy. The introduction of a brand new product innovation allows firms to earn a temporary monopolistic profit on the products sold, but entails very high research

[3] It must be acknowledged that the introduction of a product innovation often leads to the modification of existing productive processes, therefore product innovations often leads also to process innovations. This complementarity of product and process innovation has been widely acknowledged in the literature (Milgrom and Roberts, 1995). However for the sake of this analysis process innovation alone can still be considered as a good proxy of efficiency strategies: a firm that is willing to invest to increase its efficiency levels will mainly consider the introduction of process innovations.

costs and long development processes, as shown by the literature focused on the obstacles to innovation (D'Este et al., 2012). The technological learning effect typically allows firms to decrease research costs through knowledge spillovers stemming from foreign users or foreign competitors. Since research costs are of crucial importance for brand new innovative strategies, the technological learning effect, which decreases such costs, is likely to have a positive impact on this innovative strategy. The literature that focuses on the role of users in the innovative process (Von Hippel, 1986 and 2005; Malerba et al., 2007) shows that interactions with users that are able to increase the firms' competences typically lead to brand new product innovations. Bratti and Felice (2012b) confirm the positive effect on product innovation also for firms that operate on international markets with foreign customers. Moreover a growing literature has found that interactions with international customers have a high probability to increase the novelty of a firm's innovation output and eventually lead to truly new product innovations (Laursen, 2011; Fitjar and Rodriguez-Pose, 2012; Harirchi and Chaminade, 2014).

Hypothesis 2: The technological learning effect of export activity will mainly increase the incentives for firms to adopt brand new product innovation strategies.

3. The empirical strategy

3.1. A simple model

In order to test the hypotheses about the effect of exports on firms' innovative outputs, I introduce the following simple linear probability model, in line with the previous studies on the export effect on innovation and productivity. In such a setting the probability to introduce any of the different innovation strategies *y* of firm *i* is a linear function of the firm's past exporting activity.

$$y_i^s = c + \beta\, EXPO_i^{\{t-1\}} + \delta\, X_i + \mu_j + \nu_r + \rho_c + u_i \qquad (1)$$

where *s= efficiency strategy, brand new product innovation strategy*

y_i indicates whether firm *i* implemented an innovation strategy *s*. Therefore I introduce an equation for each of the two possible strategies implemented by the firm. $EXPO_i^{\{t-1\}}$ is a dummy equal to one if a firm exported in the previous period *t-1* and equal to zero if the firm did not export in time *t-1*. X_i includes a set of firm-level control variables, while μ_j , ν_r and ρ_c control respectively for sector, regional and country effects. The idiosyncratic error term is denoted by u_{it}. While the literature so far has only focused on the size and sign of the β coefficient of being an exporter, here the hypothesis is that for each firm *i* the marginal effect of exporting on innovation activities is a linear function of the technological learning effect *L* and the foreign demand effect *D* of exporting: indeed being an exporter means that a firm has been exposed in time *t-1* to the two different effects. Therefore it is possible to write:

$$\beta_i = \gamma_1\, L_i^{\{t-1\}} + \gamma_2\, D_i^{\{t-1\}} \qquad (2)$$

Where for each firm the coefficient of the export dummy depends on the specific impact of the two identified effects. Substituting (2) into (1) I obtain the following specification:

$$y_i^s = c + \gamma_1\left(L_i^{\{t-1\}} * EXPO_i^{\{t-1\}}\right) + \gamma_2\left(D_i^{\{t-1\}} * EXPO_i^{\{t-1\}}\right) + \delta X_i + \mu_j + \nu_r + \rho_c + u_i \quad (3)$$

To ease the notation the interactions terms will be simply denoted as T_1 and T_2, suppressing the time indicators, as follows:

$$y_i^s = c + \gamma_1 T_1 + \gamma_2 T_2 + \delta X_i + \mu_j + \nu_r + \rho_c + u_i \quad (4)$$

Hence the two variables of interest are $T_1=0$ if a firm did not export in *t-1* and $T_1= L_i^{\{t-1\}}$ if the firm exported in 2004. Also T_2 will be equal to zero if a firm did not export in time *t-1* and $T_2= D_i^{\{t-1\}}$ if the firm exported in the previous time period. Since the specification of the model is suitable for all firms, and not only for exporting firms, it will avoid to incur in the selection bias problems that typically occur when the analysis is performed only on exporting firms. According to the hypotheses spelled out in Section 2.2 the two coefficients γ_1 and γ_2 are likely to differ according to the type of innovation strategy considered.

3.2. Data

The data used is the EU-EFIGE/Bruegel-UniCredit dataset, a database collected within the EFIGE project (European Firms in a Global Economy), which includes detailed firm-level information about the destinations of exports and the innovation performances of a large number of manufacturing firms active in several European countries in the period 2007-2009. For this analysis I will use firm-level data from the five largest European economies: Germany, France, Italy, Spain and United Kingdom. The EFIGE dataset is an extremely rich dataset with harmonized information across the different countries about firms' structural information (size, group affiliation, ownership structure) as well as information about the labor force, the innovation strategies and the innovative investments. Moreover the database also includes detailed information on the level of internationalization (see Altomonte, Aquilante, 2012). The great advantage of the EFIGE dataset is that it has detailed information on both the innovation strategies adopted by firms and on the specific destinations of their exports. It is hence possible to know what type of innovation strategies were implemented by each firm and, for the firms who exported, the main markets of destination of their exports. Through this last information I will be able to build an index of the technological learning and foreign demand effect of exporting. The main limit of the dataset is the fact that it is only a cross-section, which makes it more difficult to address causality issues: for this reason suitable lags of exporting activity and instrumental variable strategies will be introduced in the empirical analysis.

Dependent variables.
In order to identify the possible types of innovation strategies two dependent variables will be used: each of them indicating a specific innovation strategy, as outlined in Section 2.1.

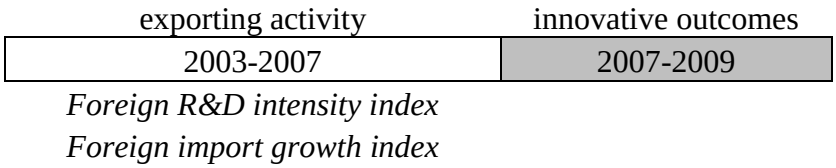
Efficiency strategies are proxied by a dummy that is equal to 1 if a firm introduced a process innovation in the time period 2007-2009 and zero otherwise.

Brand new product innovation strategies are proxied by a dummy variable that is equal to 1 if in the time period 2007-2009 a firm introduced a product innovation that is new to the market and it also applied for a patent. This combination of product innovation and patent is chosen in order to have a measure of an innovation that is really brand new and that contains an actual technological novelty. Indeed previous work with innovation surveys has shown that the fact that a firm claims to be the first to introduce an innovation might not represent a proof that the product is really innovative[4]: combining it with the application for a patent (which is necessarily linked to a technological novelty) seems a suitable way to decrease this risk.

Independent variables.

The EFIGE survey asks firms if they export. To the exporters it also asks to indicate their three main export destinations in 2008 and to specify if they were already active in those countries in 2003.[5] In order to decrease as much as possible the problems of simultaneity I only consider export destinations in which the firm was already active in the 5 years going from 2003 up to 2007: in this way I introduce a relevant time lag between exporting activity (2003-2007) and the period considered for the introduction of innovations (2007-2009). The information about export destinations also allows me to identify *long-term* export destinations, which have a high degree of persistence for the firms, since usually the positive effect of export on innovation is found for persistent innovators (Lööf et al., 2015).

Figure 1. The time lag between exporting and innovation



On the basis of this information, combining it with the sectoral affiliation of each firm, it is possible to build the two main indices that measure the technological learning effect and the foreign demand effect stemming from export activity: to each exporting firm I associate the level of foreign market growth and technological advancement of the countries in which the firm exports and specifically in the sector in which the firm is active (see Figure 2). The main assumption behind this approach is that the possibility to learn through exporting activity (technological learning) and to benefit from the increase of the foreign markets does not depend on the features and dynamics of the overall economy of the countries of destination, but only by the characteristics of the same sector in which the firm is active. As a matter of example this implies that for a German firm active in the electronic industry

[4] This is even more important when one compare exporting and non-exporting firms: the question about whether a product is new to the market or not risks to be misleading. For example a small non-exporting firm which only knows its domestic market might consider a new product with little innovative content as new to the market. On the contrary a large and internationalized firm operating in many foreign markets might consider a very innovative product as not new to the market because in some other markets it might have been already introduced by some leading competitor.

[5] The survey specifically asks firms to focus on the export activities which the firm carries out from the home country, disregarding the sales made through third countries (Altomonte, Aquilante, 2012). This distinction allows to clearly distinguish the export effect from other effects related with the internationalization activities, such as foreign direct investments or arm's length agreement of outsourcing

which exports to the United States the technological learning and foreign demand effects will depend on the characteristics and the dynamics of the electronic industry in the United States and not on the overall dynamics of the United States economy. This approach seems legitimate, since firms, especially small and medium-sized firms, are often working in a specific market niche, therefore the features of the economy at the aggregate level may have little or no influence at all on their economic decisions: a thinner, sector-based, measure is hence to be preferred. This strategy might instead not be appropriate for large multiproduct firms that operate in very heterogeneous market segments: in the empirical analysis I will then make sure that the results are robust to the exclusion of this set of firms.

However the advantages of this sectoral strategy increase only up to a certain threshold: if the sectoral disaggregation is too thin there is the risk to miss important inter-sectoral effects. Indeed a firm necessarily sells outputs to other firms that perform slightly different economic activities along the vertical supply chains. Restricting the sectoral focus too much may result in losing these interactions occurring with foreign buyers. In order to take into account both these effects the 2-digit (ISIC. Rev. 3) sectoral aggregation was chosen: this classification distinguishes between manufacturing firms that do completely different economic activities (such as the pharmaceutical industry and the automotive sector), but at the same time it aggregates across similar economic activities (such as the production of basic chemicals and the production of plastic products).[6]

Figure 2. The construction of the technological learning and foreign demand indices

Firm	*firm i active in sector j*		
Export 2003-2007		YES	NO
Main destinations of export in 2003		country_1 country_2 country_3	- - -
Technological learning effect	*highest level*	country_1 R&D intensity in sector j country_2 R&D intensity in sector j country_3 R&D intensity in sector j	0
Foreign demand effect	*average*	country_1 import growth in sector j country_2 import growth in sector j country_3 import growth in sector j	0

Technological learning effect index. The technological learning effect can be proxied by the level of technological sophistication of the country in which a firm is exporting, in the specific 2-digit sector

[6] Another possibility to catch the inter-sectoral linkages would be to use cross-sectoral input-output tables to weight each sector by its relevance among the revenues and purchases of the other sectors. This approach is complicated by the fact that- due to the impossibility to have detailed input-output data for each possible destination country- one should adopt an arbitrary world-level average of input-output tables. Even if this seems a possibly interesting avenue of research, for the time being the simpler 2-digit sectoral approach was preferred.

in which the firm is active. According to the hypotheses of the "learning by exporting" literature, the higher is the level of technological advancement of the market/sectors of destination, the higher will be the possibility for the exporting firm to acquire new knowledge and new useful routines to be eventually incorporated in new products or new processes. The share of Research and Development (R&D) expenditures over the total value added of a sector can be considered a reliable proxy of the general level of technological advancement of a sector in a country.[7] For each national sector indicated as a *long-term* export destination by the firms in the EFIGE sample, I calculated the level of business R&D intensity over value added using data from the OECD-STAN, integrating it with data from the UNIDO and the World Bank (see the Appendix for further information): to each country-sector the average value of R&D intensity for the years between 2003-2007 was used. In this way the technological intensity of export destinations corresponds to the period to which firms refer when they indicate their export-markets and, at the same time, the use of the average level of R&D intensity over the 5 years should exclude possible outliers due, for example, to sudden decreases/increases of value added in specific years, which would bias upward/downward the R&D intensity. As shown in Figure (2) The technological learning effect *L* hence corresponds to the *highest level* of R&D intensity in sector *j* among the three main countries of destinations *c* indicated by firm *i*, conditional on the fact that the firm was already exporting in those markets in 2003.[8]

$$L_i^{\{t-1\}} = \max(\mathrm{R\,\&\,D}_{cj}^{\{t-1\}}) \qquad (5)$$

Where $c = 1, \ldots, 3$

Foreign demand effect index. Contrary to the technological learning effect in the literature there are already some attempts to measure the effect of foreign demand on the innovative performances of exporting firms: Bratti and Felice (2012) use the level of GDP per capita of export destinations weighted by the relative distance. Accetturo et al. (2013) instead use import growth as a proxy of the growth of demand. Here I follow the second strategy and build an index that is equal to the average rate of growth of imports in the period 2003-2007 in each specific 2-digit sector in the three export destinations of each exporting firm. The data come from COMTRADE and are calculated in US dollars. Since I am only considering *long-term* export destinations in which firms were already active in 2003 and were still active in 2007 I can be sure that from 2003 to 2007 these firms have been continuously exporting to that specific country *c* which experienced that rate of growth of imports in sector *j*. As also shown in Figure (2) the foreign demand effect therefore is:

[7] An alternative would be to use the number of patent applications by national firms in each specific sector. However this approach is not straightforward because it is necessary to match sectorial classifications with the technological classes of patents. Moreover one should also decide which patent office should be used (either the EPO or USPTO), this would introduce another arbitrary decision. Also Total Factor Productivity (TFP) is sometimes used to assess the level of technological advancement of a national sector: however TFP is a less precise measure of technological sophistication, since its dynamics might be due to non-technological factors, such as the changes in the competition structure of a sector.

[8] Also the average level of R&D intensity among the three export destinations might be an appropriate measure of the technological learning effect: however the measure used in the paper seems preferable because it is likely that knowledge spillovers and opportunities to learn will mainly proceed from the firm's most sophisticated market. In other words using an average value means that if company A exports to only one advanced market and company B exports to an equally advanced market and a less advanced market, the average value of technological learning effect would be lower for company B. This does not seem a legitimate choice since both companies have the same opportunity to learn from the most advanced market in which they export.

$$D_i^{\{t-1\}} = \sum_{c=1}^{3} \left(imp_{jc2007} - imp_{jc2003} \right) / 3 \qquad (2)$$

Where $c = 1, \ldots, 3$

And *imp* is the log of imports from country *c* and sector *j* in time *t*. This measure is able to capture the extent to which the markets in which the firm was exporting have grown in the period before the decision to adopt any of the innovative strategies identified above. Again I adopt a lag specification in order to restrict the focus on the sectoral import growth for the period 2003-2007 of the markets in which firms were already operating in 2003. This allows to avoid a first possible reverse causality issue: indeed a growing market typically attracts exporting firm. My strategy allows to rule out this possibility: because I only consider the demand effect for markets in which firms were already there in 2003, that is, before the exogenous high (or low) growth of that market in the period 2003-2007.

Home effects. In order to isolate the export effect on innovation, it is also necessary to distinguish between the effect on innovation that is brought by foreign activity and the effect of the domestic market in which the firm is active. Therefore the model also includes a measure of the growth of the internal markets, as proxied by the growth of value added in the national 2digit sector of belonging of each firm (taken from OECD-STAN database), and a measure of the technological advancement of the sector in which the firm is active, as proxied by the share of R&D expenditures over total value added in the national 2digit sector of belonging of each firm (source OECD-STANBERD database).

Structural variables. The model includes controls for structural characteristics of the firms such as employment size, age of the firm, group affiliation (controlling whether the firms is member of a national group or foreign group) and the type of ownership control, through a dummy that indicates whether the chief executive order (CEO) is the individual who controls the firm or a member of the controlling family.

Innovative capacity. Another set of variables is related with the innovative capacity of the firm. The first variable is the percentage of the total turnover that a firm invested in R&D on average in the years 2007-2009. The model also controls for the level of human capital through a dummy equal to 1 if the firm has a higher share of graduate employees with respect to the national average share of graduates and zero otherwise. The quality of the labor force is further controlled also with a variable that measures the share of employees working for the firm with a fixed-term contract, assuming that fixed term contract are associated to lower cost of labor and hence to a lower quality of the employees. Finally, the model also includes a dummy that measures the ICT competences of firms and is equal to 1 if the firm has access to a broadband connection with high-speed transmission of digital content and zero otherwise.

Internationalization activity. In order to identify the effect of export activity on innovation strategies it is extremely important to distinguish between export activity *per s*e and internationalization activities in their broader spectrum. Indeed internationalization and export activities are intrinsically intertwined: not accounting for the former would imply the risk to have an important confounding factor that is positively correlated both with export activity and with innovation activities. This factor has often been overlooked by previous studies, with the risk to confuse between the two effects of

export and internationalization activities on innovation. The model therefore includes two dummies that control if the firm runs at least part of its production activity in another country through direct investments or through contracts and arms' length agreements with companies located in the foreign market. Another dummy variable controls if the firm has any foreign affiliates. Finally I also control for the geographic localization of the main competitors of the firm with a set of dummies that control if the firm's competitors are located in the domestic, European, or North American markets, or if they are located in other countries.

Vertical integration. Especially the technological learning effect might be affected by the level of vertical integration of a firm: as a matter of example the possibility to learn from foreign customers will change a lot if the firm sells directly to consumers or to other firms. In general, as Gereffi et al. (2005) suggests, the possibility to learn from international customers is higher for specialized suppliers who are able to upgrade their competences through repeated interactions with their clients. Therefore I introduce three dummy variables that indicate the percentage (on average) of the firms' turnover made up by sales of produced-to-order goods.

The model also controls for country effects, 2-digit sector effects and regional effects at the nuts-2 level.

3.3. Descriptive statistics

Table (1) presents the aggregate descriptive statistics of the main variables in the whole sample that includes French, German, Italian, Spanish and British firms. The most diffused innovation strategy is the efficiency strategy, which is adopted by more than 40% of firms, followed by brand new product innovation strategies, which are implemented only by 11% of firms. Firms with up to 50 employees represent the large majority of the overall sample (75%). Only a small share of firms belong to national or foreign groups – respectively 13% and 8%. The variables related with internationalization strategies show that only a limited fraction of firms (5%) has foreign direct investments abroad and about 4% chose to produce abroad through arm's length contracts with foreign partners. The majority of firms considers domestic competitors as the most important, followed by European competitors (43%) and competitors in other areas (27%).The variables that proxy the level of vertical integration show that for more than 60% of firms the sales-to-order share of their product is greater than 70%, indicating that most of the firms have established clients and they produce on the basis of their specific requests.

INSERT TABLE (1) ABOUT HERE

About 40% of firms were already exporting in 2003: for each of them it was possible to calculate their respective index of technological learning effect -as proxied by the intensity of R&D expenditures of the sectors and markets in which they were exporting in 2003- and of the foreign demand effect that is measured by the average growth of imports in their specific sector of the markets of export destination. Figures (3) and (4) display the distribution of the two indices for the subset of firms who were exporting in 2003. The two histograms are quite different: while the technological

learning effect displays a very skewed distribution, the demand effect has a more smoothed normal-like distribution. This shows that in the case of R&D intensity the majority of firms exports to markets that have values of R&D intensity below 0.2, with only a minority of firms exporting in very advanced foreign markets. On the contrary the role of outliers is much less important for the demand effect.

INSERT FIGURES (3) AND (4) ABOUT HERE

4. Results

Before estimating the impact of the technological learning and demand effect on firms' different innovative strategies I start with an OLS estimation of the linear probability models that explain the implementation of the two possible innovation strategies, using the fact of being an exporter in 2003 as the main independent variable. This will be useful for two reasons: first because it will be a benchmark with respect to the previous literature and secondly because it will allow to show how the inclusion of the different controls of the model changes the export effect on innovation.

INSERT TABLE (2) ABOUT HERE

Table (2) displays the effect of exporting on each of the innovative strategies. In columns (1) and (4) the model consists only of industry, region and country effects: the results show that exporting activity has always a positive effect on innovation and that the size of such effect is more or less equal for efficiency and brand new product innovation strategies. In columns (2) and (5) instead I introduce a first set of controls that measure the level of innovative investments and some structural characteristics of the firms such as employment, belonging to a group and the composition of the labor force. The results show that the inclusion of these controls decrease by almost 50% the coefficient of export activity in efficiency and innovative strategies. As expected the level of investments in R&D and the presence of skilled labor force is positively correlated with efficiency and innovative strategies. Finally in column (3) and (6) I introduce also the other controls related with the level of internationalization and vertical integration of each firm, as well as the sectoral measures of domestic demand growth and domestic intensity of R&D. The inclusion of these further controls decreases by roughly one third the impact of the export dummy in both specifications, showing that their inclusion is important in order to properly identify the effect of exports on innovative strategies.

INSERT TABLES (3) AND (4) ABOUT HERE

Once acknowledged the role of the different factors that should be accounted for to explore properly the effect of export activity on innovation strategies I can investigate specifically the role of the technological learning and demand effect on the different strategies implemented by firms. The underlying hypothesis is that the positive coefficient found for the export dummy in Table (4) is sometimes due to the technological learning effect and sometimes to the demand effect, according to the specific innovative strategy considered. In Columns (1) to (4) of Table (3) I substitute the export dummy with the two effects in the efficiency strategy specification. In column (1) I present the results obtained with a simple OLS introducing only the structural controls such as size, belonging to a group and those related with innovation capacity (R&D, skilled labor force, ICT): I find that only the demand indices has a positive and significant effect, while the technological learning index is not significantly different from zero. The results do not change when in column (2) I include the additional controls for internationalization activity and vertical integration: the coefficients decrease slightly but again only the demand effect is positive and significant. As already stated in Section 3.2 the procedure used to build the two indices assumes that firms are affected by the level of foreign demand and foreign technological spillovers of the sectors in which they are active. This might not be an appropriate strategy for large multinational operating in very different market segments: in that case considering only one of the various economic activities in which these firms are active would be highly misleading. To overcome this problem first in column (3) I restrict the sample to the firms that have at least 60% of their sales in one specific economic activity, then in column (4) I only consider firms with less than 500 employees, in order to exclude large multinationals. The OLS results however do not change: the only positive and significant coefficient is found for the foreign demand effect.

In columns (5) to (8) of Table (3) I test the role of the technological learning and demand effect in the brand new innovation strategy specification, following the same strategy used before. In column (1) I only include structural and innovation-capacity controls, in column (2) I include all controls, in column (3) and (4) I select respectively only firms with the majority of sales in one single type of economic activity and only firms with less than 500 employees. In this case both effects are positive and significantly different from zero in all specifications, however the coefficient of the technological learning effect is on average 50% higher than the foreign demand effect.

Summing up the OLS results of Table (2), in which the export dummy is used, show that exporting activity indeed increases the likelihood of introducing both efficiency and brand new product innovation strategies. However in Table (3) I find that the positive impact of export activities on the different innovation strategies is the result of the differentiated effects of the technological learning and foreign demand indices: more specifically the demand effect mainly increases the probability to introduce efficiency strategies, while the technological learning effect only has an impact on the probability to introduce truly innovative strategies.

4.1. Causality

The results obtained with the OLS specification might still suffer from some endogeneity issues. $D_i^{\{t-1\}}$ and $L_i^{\{t-1\}}$, i.e. the indices of imports growth and of technological development of the main countries of export destination for each firm *i*, depend on exogenous macro-economic trends in trade activities and on the general level of development of a national sector, so they do not depend on the specific innovative strategies of the firms in the sample. However the two variables might still be endogenous because the choice of a firm to export in a specific country *c* is not random: firms chose strategically the destination of their exports. The specification chosen, which considers only innovation activities performed between 2007 and 2009 and export destinations in which firms were present from 2003-2007 allows to diminish to a great extent the impact of reverse causality bias, however it does not allow to rule it out completely. Past innovative activities can still have an effect on firms' export destinations, even if there are no clear expectations about the direction of this effect. Indeed it is not straightforward to say, for instance, if a firm that implemented efficiency strategies in the past is more likely to export to destinations with low or high foreign demand: in the first case we would have a OLS downward bias of the foreign demand effect in the efficiency strategy equation, in the second case instead the OLS would be affected by an upward bias.

Moreover the fact that a firm exported in a specific country (with a specific demand growth and technological development level) in 2003-2007 might be related to the existence of unobservable third omitted factors, such as managerial ability, that the model might not be able to control for, since the sample is a cross-section. In other words there can be unobservables correlated both with the decision to implement specific innovation strategies and with the choice of specific export destinations in terms of demand growth or technological advancement.

A suitable way to overcome these potential problems is to instrument the two variables of interest T_1 and T_2 with a variable that is related with the probability to export in a specific country in 2003-2007, but which is independent of firms' specific innovation activities. Building on the previous literature on this topic (Bratti and Felice, 2012) I adopt an identification strategy that relies on the average propensity of firms in a certain national sector to export towards specific destinations. In other words I assume that in each country a firm will be more likely to export to the market destinations that are common among the other firms active in the same national sector: if the majority of exports in the German electronics industry is towards, say, US, France and Italy, it is also likely that an average exporting firm in the German electronics sector will export towards these countries. Taking advantage of OECD trade data (STAN Bilateral Trade in Goods by Industry and End-use) it is possible to retrieve for each national sector the aggregate flow of exports to each country and select the most common destinations in the period 2003-2007. On the basis of this information I build an average of import growth and of R&D intensity for the most common export market destinations of each national sector. This new variable can be considered as a good candidate instrument, since the sectoral average will be correlated with the actual export decisions of firms, while the exclusion restriction is that this measure will not be correlated with a firm's own innovation capacities.

However since it is likely that the relationship between this instrument and the actual behavior of firms will not be linear I introduce some further factors that are supposed to determine heterogeneous responses by firms to the treatment. The first factor is the regional propensity to export: the

probability that a firm exports in the same market destinations of the average firm in its own national sector also depends on the general propensity to export of the firm's region, since this propensity varies quite a lot among regions in the same countries. Another factor that is likely to diminish the ability of the instrument to explain firms' export choices is related to the size of firms: very small firms will have in general a lower ability to export, regardless of the sectoral averages, since they face relevant obstacles to access foreign markets, represented by sunk and information costs. On the basis of these preliminary considerations I built the following instrument:

$$\hat{T}_1 = \sum_{c=1}^{25} w_j L_{jc} m_r$$

L_{jc} is the level of technological development proxied by the R&D intensity of the 25 most-common c country-destinations of exports for the sector j in the specific European country in which the firm is active (France, Germany, Italy, Spain or UK). w_j is the share of export to each of the 25 most common destinations of exports over the total exports of national sector j in the period 2003-2007. m_r is the share of exporters in each region over the total number of firms in that specific region. Finally in order to account for firm-size effects an additional instrument will be added in which $\hat{T}_{1i}$ is multiplied by a dummy (0/1) equal to one if a firm employment is equal or lower than 25 employees. The same procedure is used to instrument the foreign demand effect index T_2:

$$\hat{T}_2 = \sum_{c=1}^{25} w_j D_{jc} m_r$$

Where D_{jc} is the growth of imports between 2003 and 2007 of the 25 most-common c country-destinations of exports for the sector j in the specific country in which the firm is active. w_j is the share of export to each of the 25 most common destination of exports over the total exports of sector j in the period 2003-2007. m_r is the share of exporting firms in each region on the total number of firms in that specific region. Also in this case $\hat{T}_2$ is multiplied by a dummy (0/1) equal to one if a firm employment is equal or lower than 25 employees.

In Table (4) I present the results obtained with this specific instrumental variable (IV) strategy, using a Two-Stage Least Squares (2SLS) estimator. In columns (1) to (4) I present the efficiency strategy specification in which both the foreign demand and technological learning indices are instrumented by the instruments built with the national sectoral propensities. The results in column (1) and (2) in which I use the whole sample and progressively include internationalization controls, show that only the foreign demand effect is positive and significantly. Moreover the coefficient becomes larger than the one found in the OLS estimates pointing to a downward bias in those estimates. The results hold also when I only consider firms with a dominant business activity and firms with less than 500 employees in columns (3) and (4). The first-stage F-statistics of the two instrumented variables, reported in the lower part of Table (4), are always greater than 10, that is, above the usual threshold identified by the weak instruments literature (Bound et al., 1995, see also Table 5 for first-stage regressions). Moreover the Hansen test on over-identifying restrictions shows that the instruments are exogenous to the error term and correctly excluded from the main regression.

In columns (5) to (8) I implement the same IV strategy in the brand new product innovation equation. In this case I find that in all specifications only the technological learning index is positive and significant, while the foreign demand index becomes not significantly different from zero. Again the first-stage F-statistics show that the instruments are not weak (always greater than 10) and the Hansen test confirms the exogeneity of the instruments.

Summing up the results obtained with the IV approach confirm the initial OLS results and provide even more evidence to my hypotheses: the demand effect only has an impact on the probability to introduce efficiency strategies, while the technological learning effect increases only the probability to introduce brand new product innovation strategies.

4.2. Aggregate country comparisons

Finally it is also interesting to note whether there are important country patterns in the overall level of the technological learning and foreign demand effects, given the important role that they exert in fostering different types of innovation strategies. The simplest way to investigate this is to use a very basic OLS framework to investigate the existence of country effects, controlling for both sector and size effects. In other words I compare companies active in the same sectors and of the same size in different countries and check whether the level of the two indices is significantly different. Of course this comparison can be done only for firms that actually export and for which the two indices are different from zero, therefore the analysis is performed only on this subset of firms.

In Table (6) I check whether significant country differences exist for what concerns the intensity of the technological learning and foreign demand effect of exporting: the reference country used is always Germany, which is supposed to be the most advanced country, therefore the country-dummies coefficients can be interpreted as the difference of the other countries from the German mean. In columns (1) and (3), in which I only use the country dummies, I find that in most of the countries there is a lower level of both indices with respect to the German case, however these results do not take into account the different composition mix of each national sample in terms of sector specialization and size of companies. In columns (2) and (4) I control for sector and size dummies. The results show that the technological learning effect is still stronger for German firms also after controlling for size and sectors, specifically it is significantly lower in France, Italy and Spain. The demand effect –controlling for size and sector effects- instead displays negative and significant coefficients in Spain and France, while in Italy it is slightly higher than in Germany. Therefore Table (6) suggests that German exporting firms are more exposed both to the foreign demand effect and to the technological learning effect with respect to their European counterparts. UK firms are the only one who do not display substantial differences with respect to German ones. Italian companies display an average lower value for the technological learning effect and a slightly higher foreign demand effect. French and Spanish firms show significantly lower levels of both indices.

INSERT TABLE (6) ABOUT HERE

5. Conclusions

This paper shows that the positive effect of export activity on innovation among European firms is driven by two main effects: the technological learning and the foreign demand effect. The technological learning effect affects firms' strategies because it provides knowledge spillovers from foreign customers or competitors in very technologically advanced markets: this is likely to reduce the internal research costs needed to develop brand new product innovations. On the contrary the foreign demand effect of exporting activities affects firms' strategies by increasing the potential output (units sold) of a firm. In the paper I build two indices that are able to proxy these two effects through the use of R&D intensity data at the sectoral level of the destination countries (for the technological learning effect) and the growth of sectoral imports of the destination countries (for the foreign demand effect). I introduce these two indices in a linear probability model that explains the adoption of respectively efficiency and brand new product innovation strategies by European firms included in the EFIGE dataset. In the model I also take into account potential endogeneity problems stemming from firms' strategic choice of export destinations and implement an instrumental variable strategy aimed at avoiding reverse causality bias. The results of the empirical analysis show that the technological learning effect has a positive effect on the introduction of brand new product innovations, in which research costs are very high, on the contrary the demand effect of exporting activity mainly induces efficiency innovation strategies (proxied by process innovations), since these strategies become more profitable as the number of units sold increases.

The paper contributes to the literature on export and innovation in a number of ways. First it highlights the importance of export destinations to properly understand the effect of export on innovation activities. Indeed export destinations with different combinations of these two effects will also provide different incentives to innovate for firms. Secondly the paper shows that in order to understand the effect of exporting activity on innovation it is important to analyze the proper incentives to adopt specific innovation strategies. Innovation is not a homogeneous bundle of activities: firms introduce differentiated types of innovations on the basis of economic rationales, which should be properly accounted for in order to understand how exporting activity affects innovation strategies.

Though this paper provides an interesting perspective on the effect of exporting activity on innovation it also has some limitations. In the technological learning index the use of R&D intensities to measure the level of technological development of a national sector might not be appropriate for many medium and low-tech sectors that do not rely a lot on formalized knowledge. However with respect to alternative indicators R&D expenditures still have the great advantage of being a highly reliable indicator of technological development and they are also available at the sectoral level for a very high number of countries. An additional limitation of the study is that it only considers the long-run effect of export activity on the innovation activities of firms, i.e. it focuses on the subset of firms who were already exporting in 2003, while it does not account for possible short run effects of export activity occurring to firms that started to export after 2003. This problem is partially mitigated by the evidence found in the literature that studied the learning-by-exporting effect according to which only persistent exporters are really able to benefit from exporting activity in terms of innovation outcomes (Andersson and Loof, 2009; Lööf et al., 2015).

Notwithstanding these shortcoming it is still important to analyze how these results can be useful from a policy perspective, also in light of the different country patterns found in the paper. It must be stressed that while all types of innovation strategies can have a positive impact on firms' performances, in advanced economies research-based brand new product innovations -able to actually shift the world technological frontier- are those with the highest economic impact (Acemoglu, Aghion, Zilibotti, 2006) and also at the firm-level they are likely to have a greater effect on total factor productivity growth (Duguet, 2006). In a country in which firms export only to high growth markets with little levels of technological development firms might be induced to innovate only to increase efficiency, without putting enough efforts to develop truly innovative products. This might end up in a typical "development trap" (Acemoglu, Aghion, Zilibotti, 2006), according to which an economy is never able to approach and shift the technological frontier and always remains a laggard country. The country patterns investigated in the descriptive statistics of this paper show that even after controlling for firms' size and for sectoral affiliation German firms that export have higher levels of the index that measures the technological learning effect with respect to the other European countries, and especially with respect to France, Italy and Spain. These features suggest that in these countries also exporting firms might lack an important incentive to introduce research-based product innovations that are able to increase their future innovative capacities and induce catch up processes within the European Union.

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Table 1. Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max
Dependent variables				
Efficiency strategy	0.438	0.496	0	1
Brand new prod. innovation strategy	0.114	0.317	0	1
Independent variables				
Export activitiest				
Export in 2003	0.411	0.492	0	1
Demand effect	0.058	0.077	-0.164	0.610
Technological Learning effect	0.026	0.066	0	0.735
Structural variables				
employment(≤25)	0.470	0.499	0	1
employment(>25 and ≤50)	0.283	0.450	0	1
employment(>50 and ≤100)	0.111	0.314	0	1
employment(>100 and ≤150)	0.041	0.197	0	1
employment(>150 and ≤250)	0.033	0.180	0	1
employment(>250 and <500)	0.037	0.189	0	1
employment(≥500)	0.026	0.160	0	1
Share of fixed term contracts	26.773	38.902	0	100
Firm age (<6 years)	0.338	0.473	0	1
Firm age (6-20 years)	0.338	0.473	0	1
Firm age (>20 years)	0.594	0.491	0	1
National group	0.137	0.344	0	1
Foreign group	0.081	0.273	0	1
Family member as CEO	0.631	0.482	0	1
Innovative capacities				
Share of R&D	0.037	0.076	0	1
Skilled labor force	0.281	0.449	0	1
fixedt	26.787	38.923	0	100
ICT access	0.914	0.280	0	1
Internationalization variables				
Foreign Direct Investments	0.049	0.216	0	1
Arms' length foreign production	0.040	0.197	0	1
Domestic affiliates	0.133	0.339	0	1
Foreign affiliates	0.075	0.263	0	1
Domestic competitors	0.855	0.352	0	1
Competitors in EU	0.431	0.495	0	1
Competitors in US	0.126	0.332	0	1
Competitors other geo areas	0.273	0.445	0	1
Vertical integration				
Sales to order share (1-30%)	0.120	0.325	0	1
Sales to order share (30%-70%)	0.088	0.284	0	1
Sales to order share (>70%)	0.662	0.473	0	1
Domestic effects				

Growth of domestic sector	0.116	0.126	-0.646	0.673
R&D intensity domestic sector (%)	3.392	5.996	0.106	51.061

National composition	num. firms	(%)
France	2,723	21.1
Germany	2,827	21.91
Italy	2,950	22.86
Spain	2,728	21.14
UK	1,677	12.99
Total number of observations	12905	100

Figure 2: The technological learning effect index

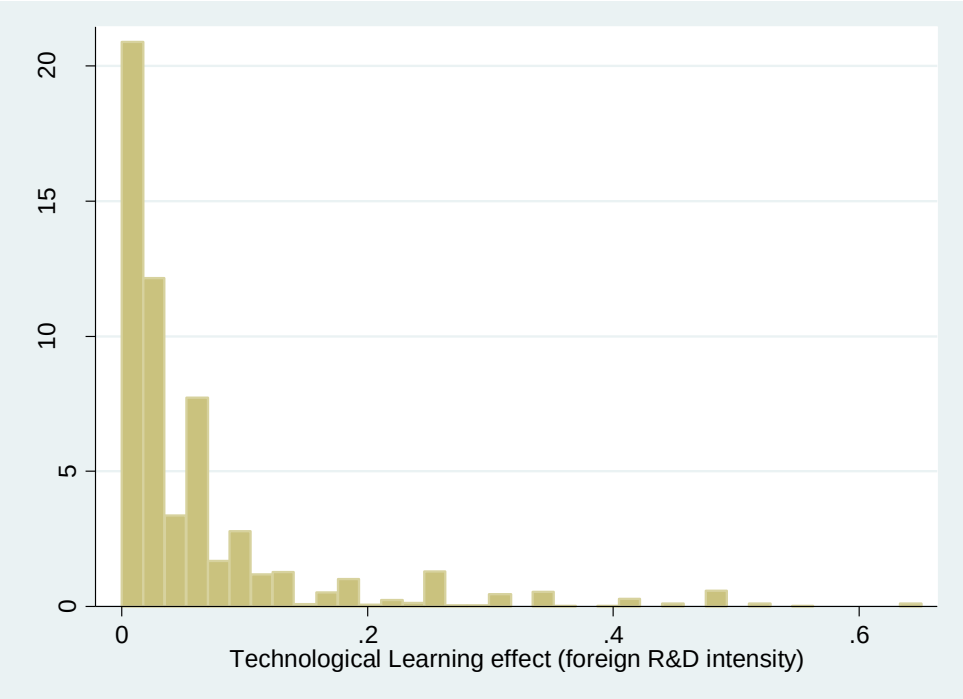

Figure 3: The foreign demand effect index

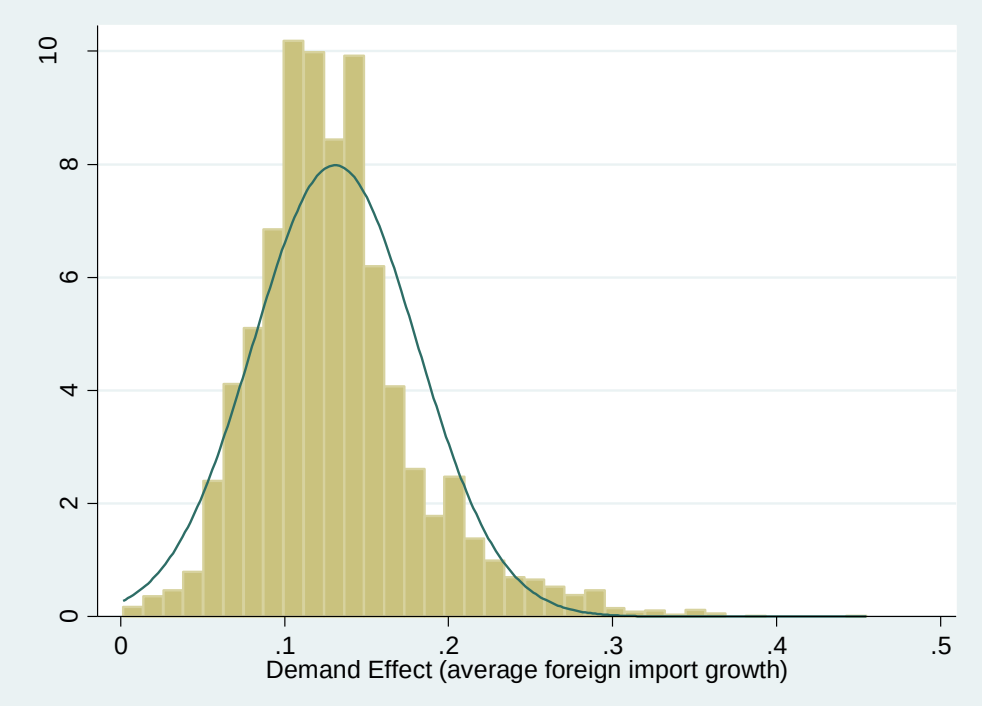

Table 2. The effect of exports on innovation strategies

	(1)	(2)	(3)	(4)	(5)	(6)
	Efficiency strategy			Brand new product innovation strategy		
Export	0.096***	0.052***	0.037***	0.093***	0.054***	0.034***
	(0.009)	(0.010)	(0.010)	(0.006)	(0.006)	(0.006)
Share of R&D		0.908***	0.884***		0.742***	0.683***
		(0.069)	(0.069)		(0.056)	(0.056)
Skilled labor force		0.048***	0.043***		0.035***	0.028***
		(0.010)	(0.010)		(0.006)	(0.006)
National group		0.006	0.002		0.011	0.001
		(0.014)	(0.014)		(0.009)	(0.009)
Foreign group		0.006	0.002		0.029**	0.017
		(0.018)	(0.018)		(0.014)	(0.014)
employment(>25 and ≤50)		0.076***	0.072***		0.027***	0.022***
		(0.010)	(0.010)		(0.006)	(0.006)
employment(>50 and ≤100)		0.125***	0.117***		0.074***	0.056***
		(0.015)	(0.015)		(0.010)	(0.010)
employment(>100 and ≤150)		0.156***	0.143***		0.134***	0.104***
		(0.023)	(0.023)		(0.018)	(0.018)
employment(>150 and ≤250)		0.215***	0.202***		0.175***	0.136***
		(0.025)	(0.025)		(0.022)	(0.021)
employment(>250 and <500)		0.177***	0.163***		0.153***	0.100***
		(0.025)	(0.025)		(0.020)	(0.020)
employment(≥500)		0.209***	0.186***		0.251***	0.156***
		(0.030)	(0.031)		(0.026)	(0.026)
Firm age (6-20 years)		-0.030	-0.027		-0.010	-0.010
		(0.018)	(0.018)		(0.011)	(0.011)
Firm age (>20 years)		-0.041**	-0.039**		-0.016	-0.020*
		(0.018)	(0.018)		(0.011)	(0.011)
Family member as CEO		0.023**	0.022**		0.003	0.004
		(0.010)	(0.010)		(0.006)	(0.006)
Growth of domestic sector		0.033	0.052		0.040	0.059
		(0.071)	(0.070)		(0.048)	(0.048)
R&D intensity domestic sector		0.004**	0.004**		-0.000	-0.000
		(0.002)	(0.002)		(0.001)	(0.001)
Share of fixed term contracts		-0.000	-0.000		-0.000	-0.000
		(0.000)	(0.000)		(0.000)	(0.000)
ICT access		0.034**	0.031**		0.021**	0.016**
		(0.015)	(0.015)		(0.008)	(0.008)
Domestic affiliates			0.019			0.022**
			(0.013)			(0.010)
Foreign affiliates			0.006			0.119***
			(0.020)			(0.017)
Foreign Direct Investments			0.020			0.060***

			(0.023)			(0.021)
Arms' length foreign production			-0.019			0.070***
			(0.022)			(0.018)
Sales to order share (1-30%)			-0.013			0.014
			(0.017)			(0.011)
Sales to order share (30%-70%)			-0.018			-0.000
			(0.019)			(0.012)
Sales to order share (>70%)			0.031**			-0.020**
			(0.014)			(0.008)
Domestic competitors			0.031**			-0.032***
			(0.013)			(0.009)
Competitors in US			0.045***			0.062***
			(0.015)			(0.011)
Competitors in EU			0.056***			0.011*
			(0.010)			(0.007)
Competitors other geo areas			0.024**			0.001
			(0.011)			(0.007)
Constant	0.071	-0.004	-0.030	-0.054	-0.173*	-0.130
	(0.168)	(0.205)	(0.214)	(0.037)	(0.096)	(0.096)
Observations	12,905	12,905	12,905	12,905	12,905	12,905
R-squared	0.037	0.073	0.080	0.073	0.138	0.164

All models are estimated with Ordinary Least Squares estimator (OLS). All model include country, sector and region fixed effects. The reference category for firms' size is less than 25 employees. The reference category for firms' age is less than 6 years. The reference category for sales to order share is zero. Standard errors in parentheses are clustered at the firm level *** p<0.01, ** p<0.05, * p<0.1

Table 3. The effect of technological learning and foreign demand

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Efficiency strategy				Brand new product innovation strategy			
Technological Learning effect	0.134	0.105	0.125	0.103	**0.314*** **	**0.259*** **	**0.253*** **	**0.234*** **
	(0.085)	(0.085)	(0.089)	(0.088)	**(0.070)**	**(0.070)**	**(0.072)**	**(0.071)**
Demand effect	**0.255*** **	**0.173** **	**0.144** **	**0.157** **	**0.264*** **	**0.162*** **	**0.165*** **	**0.160*** **
	(0.067)	**(0.068)**	**(0.071)**	**(0.069)**	**(0.046)**	**(0.047)**	**(0.048)**	**(0.047)**
Innovative capacity controls	yes	yes	yes	yes	yes	yes	yes	yes
Internationalization controls	no	yes	yes	yes	no	yes	yes	yes
Observations	12,905	12,905	12,195	12,564	12,905	12,905	12,195	12,564
R-squared	0.073	0.080	0.084	0.080	0.141	0.166	0.166	0.150

All models are estimated with Ordinary Least Squares estimator (OLS) and include country, sector and region fixed effects. In columns (1) to (4) the dependent variable is the adoption of efficiency strategies, in columns (5) to (8) the dependent variable is the adoption of brand new product innovation strategies. In columns (3) and (7) only firms with at least 60% of their sales in a specific business are included, in columns (4) and (8) only SME firms with less than 500 employees are included. Standard errors in parentheses are clustered at the firm level *** p<0.01, ** p<0.05, * p<0.1

Table 4. The effect of technological learning and foreign demand - Instrumental Variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Efficiency strategy				Brand new product innovation strategy		
Technological Learning effect	0.425	0.436	0.446	0.218	**1.355*** **	**1.327*** **	**1.326*** **	**1.236*** **
	(0.497)	(0.515)	(0.557)	(0.531)	**(0.383)**	**(0.392)**	**(0.431)**	**(0.401)**
Demand effect	**1.998** **	**2.066** **	**2.043** **	**1.678***	0.648	0.635	0.881	0.247
	(0.890)	**(0.989)**	**(0.965)**	**(1.005)**	(0.548)	(0.603)	(0.604)	(0.606)
Innovative capacity controls	yes	yes	yes	yes	yes	yes	yes	yes
Internationalization controls	no	yes	yes	yes	no	yes	yes	yes
IV First-stage F-statistics								
Technological Learning effect	15.08	14.21	11.97	10.57	15.08	14.21	11.97	10.57
Demand effect	12.49	11.25	11.90	12.93	12.49	11.25	11.90	12.93
Num. of instruments	4	4	4	4	4	4	4	4
Hansen statistics	0.013	0.014	0.071	0.005	1.142	1.297	3.528	1.205
p-value	0.993	0.992	0.964	0.997	0.565	0.522	0.171	0.547
Observations	12,905	12,905	12,195	12,564	12,905	12,905	12,195	12,564

All models are estimated with a Two-Stage Least squares estimator and include country, sector and region fixed effects. In columns (1) to (4) the dependent variable is the adoption of efficiency strategies, in columns (5) to (8) the dependent variable is the adoption of brand new product innovation strategies. In columns (3) and (7) only firms with at least 60% of their sales in a specific business are included, in columns (4) and (8) only SME firms with less than 500 employees are included. Standard errors in parentheses are clustered at the firm level *** p<0.01, ** p<0.05, * p<0.1

Table 5. First-stage statistics

First stage	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Technological learning effect				Foreign demand effect			
T_1	1.764***	1.720***	1.694***	1.705***	-0.213	-0.278**	-0.281**	-0.249*
	(0.269)	(0.265)	(0.277)	(0.271)	(0.135)	(0.134)	(0.138)	(0.136)
T_1*emp≤25	-0.681***	-0.682***	-0.596***	-0.588***	0.204***	0.199***	0.214***	0.204***
	(0.161)	(0.159)	(0.167)	(0.161)	(0.070)	(0.069)	(0.072)	(0.070)
T_2	0.304*	0.247	0.212	0.262	1.262***	1.137***	1.231***	1.117***
	(0.170)	(0.169)	(0.174)	(0.174)	(0.257)	(0.248)	(0.254)	(0.253)
T_2*emp≤25	0.041	0.059	0.044	0.037	-0.507***	-0.464***	-0.469***	-0.458***
	(0.069)	(0.068)	(0.071)	(0.069)	(0.095)	(0.093)	(0.094)	(0.094)
Structural and innovation controls	yes	yes	yes	yes	yes	yes	yes	yes
Internationalization controls	no	yes	yes	yes	no	yes	yes	yes
F-statistics	15.08	14.21	11.97	10.57	12.49	11.25	11.90	12.93
Observations	12,905	12,905	12,195	12,564	12,905	12,905	12,195	12,564

This table reports the first stage statistics for the instruments used in the IV Two Stages Least Squares Estimator in Table (4) (see section 4.1 for details). In columns (3) and (7) only firms with at least 60% of their sales in a specific business are included, in columns (4) and (8) only firms with less than 500 employees are included.

Table 6. Cross country differences in Technological Learning and Demand effects

	(1)	(2)	(3)	(4)
	Technological Learning effect		Foreign demand effect	
reference category: Germany				
France	-0.009**	-0.008***	-0.005**	-0.004**
	(0.004)	(0.003)	(0.002)	(0.002)
Italy	-0.020***	-0.005**	0.000	0.004**
	(0.003)	(0.002)	(0.002)	(0.002)
Spain	-0.031***	-0.017***	-0.007***	-0.006***
	(0.004)	(0.002)	(0.002)	(0.002)
United Kingdom	0.010**	-0.004	-0.002	0.001
	(0.005)	(0.003)	(0.003)	(0.002)
sector fixed effects	no	yes	no	yes
employment dummies	no	yes	no	yes
Constant	0.073***	0.023*	0.145***	0.219***
	(0.003)	(0.012)	(0.001)	(0.055)
Observations	5,300	5,300	5,300	5,300
R-squared	0.025	0.646	0.003	0.374

All models are estimated with normal Ordinary Least Squares estimator (OLS). Standard errors in parentheses are clustered at the firm level.

APPENDIX

The technological learning effect index

In order to build the index I used data on the share of business Research and Development Expenditures over value added at the sectoral level for all the countries of destination indicated by firms in the EFIGE survey for the period 2003-2007. Table A1 shows the 2-digit sectors used in the analysis. The main source of data is the data on "R&D intensity of manufacturing sectors 1995-2009 (ISIC REV. 3.1.)" provided by the Structural Analysis (STAN) Databases of the OECD. For a limited set of European countries (Cyprus, Latvia, Lithuania, Malta and Romania) for which STAN data was not available I used the "Share of R&D expenditure in value added" as provided by the Structural Business Statistics from EUROSTAT. For China, Russia, Taiwan, Singapore, Chile and South Africa data on R&D expenditures have been retrieved from "Business enterprise R-D expenditure by industry (ISIC REV. 3.1.)", while the data on value added have been retrieved from the freely-available sectoral UNIDO database.[9] The EFIGE exporting firms used in the analysis also indicated as destination of exports some middle or low income countries for which no sectoral data on R&D intensity is available: the only available information is the overall level of R&D intensity at the country level from World Bank data. In this case I imputed the level of R&D intensity in each sector applying the following strategy. I computed the ratio x_c between the overall R&D intensity of High Income Countries and the R&D intensity of the countries with missing R&D data, using the data and the classification of High-Income Country provided by the World Bank. Then I used the available data on sectoral R&D intensity from STAN and EUROSTAT to compute the average R&D intensity for High Income OECD Countries for each sector *j*. Then for each developing country I multiplied the average High Income R&D intensity in each sector ($R\&D_{HIj}$) by the ratio x_c, as follows:

$$\mathrm{R\&D_{cjt}} = x_c * R\&D_{Cjt}$$

Among OECD countries the R&D data for Switzerland proceed both from the OECD (for the majority of sectors), while for the "Basic Metals" sector (C27) and for the "Machinery and Equipment" sector (C29) data from the Swiss National Statistical Office has been used. Moreover due to the fact that no available data for Switzerland is present on value added in "Pharmaceuticals" (C2423), as distinguished from "Chemicals" (C24 *less* 2423), the intensity of R&D for both sectors has been set equal.

The foreign demand effect index

The index was built using COMTRADE data (UN) on the yearly level of imports measured in US dollars, disaggregated at the 2-digit level, i.e. for each sector in each country. The data have been used to obtain the average growth of imports from each country *c* and each sector *j* in the period 2003-2007.

[9] For these countries the R&D intensity of the chemical and pharmaceutical sector has been put at the same level, since the dataset of UNIDO on sectoral value added did not distinguished between the two sectors.

Table A1. Sectors used

CODE (ISIC REV 3.1)	SECTOR
15-16	FOOD PRODUCTS, BEVERAGES AND TOBACCO
17-19	TEXTILES AND TEXTILE PRODUCTS, LEATHER AND FOOTWEAR
20	WOOD AND PRODUCTS OF WOOD AND CORK
21-22	PULP, PAPER, PAPER PRODUCTS, PRINTING AND PUBLISHING
23	COKE, REFINED PETROLEUM PRODUCTS AND NUCLEAR FUEL
23 LESS 2423	CHEMICALS EXCLUDING PHARMACEUTICALS
2423	PHARMACEUTICALS
25	RUBBER AND PLASTICS PRODUCTS
26	OTHER NON-METALLIC MINERAL PRODUCTS
27	BASIC METALS
28	FABRICATED METAL PRODUCTS, except machinery and equipment
29	MACHINERY AND EQUIPMENT, NEC
30	OFFICE, ACCOUNTING AND COMPUTING MACHINERY
31	ELECTRICAL MACHINERY AND APPARATUS, NEC
32	RADIO, TELEVISION AND COMMUNICATION EQUIPMENT
33	MEDICAL, PRECISION AND OPTICAL INSTRUMENTS
34	MOTOR VEHICLES, TRAILERS AND SEMI-TRAILERS
35	OTHER TRANSPORT EQUIPMENT
36	MANUFACTURING NEC

Table A2. Sources of R&D intensity data

COUNTRY	SOURCE OF DATA	COUNTRY	SOURCE OF DATA
Algeria	WORLD BANK	Lithuania	EUROSTAT
Argentina	WORLD BANK	Malta	EUROSTAT
Australia	STAN	Mexico	STAN
Austria	STAN	Morocco	WORLD BANK
Belgium	STAN	Netherlands	STAN
Brazil	WORLD BANK	New Zealand	STAN
Canada	STAN	Norway	STAN
Chile	STAN + UNIDO	Poland	STAN
China	STAN + UNIDO	Portugal	STAN
Colombia	WORLD BANK	Romania	EUROSTAT
Cuba	WORLD BANK	Russia	STAN + UNIDO
Cyprus	EUROSTAT	Saudi Arabia	WORLD BANK
Czech Republic	STAN	Singapore	STAN + UNIDO
Denmark	STAN	Slovak Republic	STAN
Egypt	WORLD BANK	Slovenia	STAN
Estonia	STAN	South Africa	STAN + UNIDO
Finland	STAN	South Korea	STAN
France	STAN	Spain	STAN
Germany	STAN	Sweden	STAN
Greece	STAN	Switzerland	STAN + SWISS STATISTICAL INSTITUTE
Hungary	STAN		
Iceland	STAN	Taiwan	STAN + UNIDO
India	WORLD BANK	Tunisia	WORLD BANK
Ireland	STAN	Turkey	STAN
Israel	STAN	Ukraine	WORLD BANK
Italy	STAN	United Arab Emirates	WORLD BANK
Japan	STAN	United Kingdom	STAN
Latvia	EUROSTAT	United States	STAN