Learning from trade through innovation: Causal link between imports, exports and innovation in Spanish and Slovenian microdata*

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Abstract

The paper explores the learning from trade hypothesis. We argue that the existing literature may have failed to find significant learning effects from trade as it concentrated solely on exports as a source of firm potential learning from foreign markets. Another drawback seems to lie in the fact that most of the empirical papers focused on firm's learning effects in the form of total factor productivity improvements. In contrast, this papers defines a firm learning from trade in terms of introduction of either new products or processes induced by its import and export links with foreign markets. By using microdata for Spain and Slovenia, including data on innovation and trade, we find clear sequencing between imports, exports and innovation. The results suggest that firms learn primarily from import links, which enables them to innovate products and processes and to dress up for starting to export. In a sequence, exporting may enable firms to introduce further innovations. These positive learning effects from trade, however, seem in both samples of data to be limited to small and partially medium firms only. On the other side, Spanish firms that are more distant to the relevant technological frontier seem to benefit more from trading activities in terms of innovation than the technological front-runners. In Slovenia, firms' distance from the relevant technology frontier seems to be less important than size for learning effects from trade.

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1 Introduction

Recent literature dealing with the impact of trade on firm performance has found it difficult to provide a convincing explanation for how firms learn from trade, i.e. how firm's foreign trade participation feeds back into their performance. Primarily, this is due to the fact that the literature is predominantly focusing solely on exports. Here, the existing theoretical models in the tradition of Melitz (2003) with heterogenous firms and randomly assigned productivities fall short of explaining why some firms are initially "better", enabling them to start exporting. Studies dealing with the impact of imports on firm performance are rather scarce. If at all, than imports are studied primarily as a source of increased competition in the local markets forcing firms to adjust to increased competitive pressures. Recently, Amiti and Konings (2007) study the effects of import liberalization on plant productivity of Indonesian firms both through tougher import competition as well as through access to cheaper intermediate inputs. They show that access to cheaper intermediates might have a 10 times larger impact on firm productivity gains than that of increased import competition. Similarly, Altomonte et al (2008) show superior effects of importing reative to exporting for firm performance.

Yet another reason for failing to find conclusive evidence on firm learning effects from trade may lie in inappropriate accounting for the learning effects from trade participation. Aw et al. (2005) argue that a number of studies that failed to find evidence of learning-by-exporting may have neglected a potentially important element of the process of productivity change: the investments made by firms to absorb and assimilate knowledge and expertise from foreign contacts. This means that both importing as well as exporting activities may have helped firms to become more innovative in terms of their production processes or products, which may impact productivity growth and/or firm survival in the long run. Hence, one might not expect immediate impact of trade participation on firm productivity growth, but should study the changes a firm is introducing in subsequently to trade participation both in terms of the product structure and their characteristics as well as in terms of the organization of its production processes.

In this paper we propose to alter the usual approach to studying firm learning effects from trade. Instead of using the total factor productivity growth approach, we study firm learning from trade in terms of introduction of new products or processes following its engagement in either import or export activities. Specifically, we study the sequencing of firm's learning from trade through its engagement in imports, the decision to start product or process innovation, the decision to start exporting and to further product or process innovations induced by exports. We expect that firms with extensive importing links are more likely to introduce new products or processes, which will help them to "dress up" for the upcoming decision to start exporting. Exporting, in turn, may further boost product and process innovation. All these activities could concivably translate into firm productivity gains.

In order to study this sequencing of firm learning effects from international trade links, we make use of the rich panel datasets for Spain (1991-1999) and Slovenia (1996-2002) combining usual firm-level accounting data with the data on innovation and trade flows. We employ matching techniques to explore the exact sequencing between firm's engagement in trade and its learning from trade through innovation. Our results suggest that firms learn significantly from their import activities both in terms of product and process innovations. Engagement in imports and innovation activity are then shown to trigger the decision to start exporting. Exporting in turn induces further innovations. This sequencing, however, is found in both country datasets to be important predominantly for small and partially for medium-sized firms. On the other hand, firms that are more distant to the relevant technological frontier seem to benefit more from trading activities in terms of innovation than the technological front-runners. In other words, small and technologically laggard firms are found to learn comparatively more from trade, which is essential for their catching up in terms of productivity. These results are important in terms of understanding the impact of trade on firm performance and may find applications in the trade models with heterogeneous firms, which should put more emphasis both on imports as well as on firm's innovation activities.

The paper is outlined as follows. Next Section provides review of the relevant literature. Section 3 presents the data and methodology is explained in Secrion 4. Section 5 presents the empirical results and the last Section concludes.

2 Literature review

During the last two decades, a vast literature has addressed the issue of firm learning from its international transactions. Impact of international knowledge spillovers on firm performance has been studied in their various forms - from outsourcing, over spillovers from FDI to learning-by-exporting. Though extensive, the evidence found in the literature does not provide much support in favor of any of these various forms of international knowledge spillovers. While direct technology transfer from parent companies to their affiliates worldwide has been shown conclussively to increase affiliates' perfomance, no conclusive evidence has been found in favor of local firms learning through horizontal spillovers from the competition of foreign affiliates in the same industries (Görg and Greenaway, 2004).[1] Similarly, another strain of the literature exploring the learning-by-exporting hypothesis, found quite striking evidence in favor of self-selection of initially more productive firms into exporting rather than learning from their exporting activities (see Greenaway and Kneller (2007) for a survey of empirical studies and Wagner et al (2009) for a consistent cross-country study for 14 countries).

Recent literature falls short of finding a convincing explanation for why some firms are initially "better" and how foreign trade participation feeds back into firm's productivity. Foster et al. (2006) provide some evidence in favor of this by showing that firm-specific demand variations, rather than technical efficiency, are the essential determinants of firm survival, and they positively affect firm productivity. This finding implies that a firm's product innovation due to positive demand shocks may explain a large portion of a firm's higher pre-trade productivity level and its consequent decision to start exporting. A recent study by Cassiman and Golovko (2007) shows for a sample of small and medium Spanish firms that controlling for product innovation causes the differences in productivity among exporting and non-exporting firms to disappear. In a related paper, Cassiman and Martinez-Ros (2007), find for a sample of Spanish firms that engaging in product innovation significantly increases the probability to start exporting. Similarly, Becker and Egger (2007) find, after controlling for the endogeneity of innovation, that product innovation in the case of German firms plays an important role in increasing the propensity to export, while they find no such evidence for process innovation. Salomon and Shaver (2005) find some evidence in Spanish microdata that past exporting status increases the propensity of firms to innovate. Damijan et al (2008) extend this evidence by finding that exporting may increase the probability of becoming a process rather than product innovator in a sample of medium sized Slovenian first-time exporters, and that exporting later on may lead to productivity improvements. These findings suggest that product innovations may increase the likelihood of firms starting to export, while participation in trade may positively affect firm efficiency by stimulating process innovations. Damijan et al (2008) hence argue that there must exist a causal link between a firm's innovation effort, its overall productivity level and the decision to start exporting as well as between firm's exporting performance and its further improvements in productivity.

In spite of substantial advances there is still no convincing theory explaining the directionality of the link between firm innovation, participation in trade and productivity improvements. Theoretical models in the tradition of Melitz (2003) lack both a convincing explanation of what generates firm's pre-trade productivity as well as how participation in trade translates into individual firm's productivity improvements. These models assume that productivity is assigned

[1] Instead, direct upstream and downstream demand - supply links between foreign affiliates and local firms in vertically integrated industries have been found important (Damijan et al, 2003; Smarzynska-Javorcik, 2004).

to a firm by luck of draw from a random distribution, but after making a draw, there is no way for a firm to change its life path - its survival or death. Trade liberalization and participation in trade may induce intra-industry reallocations and increase the aggregate productivity, but not the one of the individual firms.

Some recent theoretical work tries to link firm individual ability to innovate and its later decision to start exporting. Bernard et al. (2006) assume firm productivity in a given product to be a combination of firm-level "ability" and firm-product-level "expertise". While they still rely on the assumption that both firm-level "ability" and firm-product-level "expertise" are exogenous, their contribution lies in emphasising the importance of a firm's ability to innovate new products. Recent work by Constantini and Melitz (2007) is the first example of a model of industry dynamics that includes endogenous innovation and export decisions. They show that anticipation of trade liberalization may lead firms to bring forward the decision to innovate, in order to be ready for future participation in the export market. This recent theoretical work emphasizing the importance of investment in product innovation as a key to explaining a firm's productivity and its decision to start exporting is also backed by a number of empirical studies finding a positive impact of innovation on exporting [Wagner (1996), Wakelin (1997, 1998), Ebling and Janz (1999), Aw et al. (2005), Girma et al. (2007)]. A link leading from the export participation to the learning effects, however, has yet to be demonstrated more convincingly. So far we have some evidence of a positive impact from export participation on either process innovations (Damijan et al, 2008) and productivity improvements (De Loecker, 2007; Damijan et al, 2008) for Slovenia only.

This, however, explains only a minor part of the puzzle of learning from trade participation. We still lack a consistent theory and evidence on (i) how firms learn from participating in trade, (ii) how it is related to firm innovation activities, and (iii) what (if at all) is the exact sequencing between innovation and trade participation. International business literature suggests that firms engaging in either import or export activities are likely to gain from the contacts with their suppliers and customers as well from the increased competition faced in larger foreign markets. It follows that a firm starting to export to foreign markets has to engage in adjusting to different technical standards and making ongoing quality improvements leading at least to improved product characteristics. But serving foreign markets with specific demand patterns may as well result in newly developed products tailor-made to the needs of specific markets. Based on the features of now standard new trade theories building on monopolistic competition and increasing returns to scale, exporting to a larger foreign market may enable firm to exploit the benefits of increasing returns to scale. This may go hand in hand with optimization of production processes, modernization of organization or introduction of new technologies, leading to improved technical efficiency. Exporting, hence, is likely to result in product and process innovations.

On the other side, importing has attracted much less attention in empirical studies as a source of important knowledge spillovers. Recently, Amiti and Konings (2007) provide estimates of the effects of trade liberalization on plant productivity by distinguishing between productivity gains that arise from tougher import competition relative to those arising from access to cheaper intermediate inputs. By using the Indonesian microdata, they find that benefits arising from lower tariffs on intermediate inputs might have 10 times larger impact on firm productivity gains than that of increased import competition. Furthermore, recent study by Altomonte et al (2008) using the Hungarian microdata demonstrates that the impact of imports on firm performance is several times more important than the the one stemming from firm's engagement in exporting. This study also shows a clear sequencing of firm trade participation. A firm engages in imports first by importing either capital goods or intermediates as either these goods are not available at home at all or it can acquire these goods at a cheaper price abroad than at home. Exporting starts only later after a firm "dresses up" sufficiently in terms of productivity in order to bear the fixed entry cost to foreign markets.

While these productivity gains from importing seem plausible it is less clear how they are related to firm innovation activities. Kotabe (1990) examines whether offshore sourcing by U.S. firms induces or dampens their innovative ability. By using industry level data, he finds some support for the complementarity between outsourcing and innovativeness of U.S. multinationals. Other related studies on firm imports and innovative activity deal with imports as a industry-wide competitive force which pushes firm to innovate in order to maintain its market position. Bertschek (1995) by using German microdata shows that both import share and foreign-direct-investment-share industry-wide have positive and significant effects on firm product and process innovations due to increased local market competition. On the other hand, Aghion et al. (2005) build on the hypothesis by Kamien and Schwartz (1972) that the relationship between product market competition and the extent of innovation may take the form of an inverted U. Specifically, their model assumes that increased competition discourages laggard firms from innovating, but encourages "neck-and-neck" firms to innovate. By using industry level data, Aghion et al. (2005) find support for the inverted U-shape relationship between competition and innovation. By using microdata for UK and U.S., Aghion et al. (2006) show that technologically advanced entry by foreign firms has a positive impact on innovation in sectors which are close to the frontier and that the effect of entry on total factor productivity growth is negatively associated with the distance to the frontier. Using microdata for 27 transition economies, Gorodnichenko et al (2008) don't find support for the inverted U effect of competition on innovation, but find that competition has a negative effect on innovation, especially for firms further from the frontier, while the supply chain of multinational enterprises and international trade are found as important sources for domestic firm innovation.

Based on the discussion so far we will argue that (i) learning from trade is associated with firm innovation activity, and (ii) that there has to be a clear sequencing between various forms of trade links and the firm's innovation activity. Regarding the first point, we draw upon the Aw et al. (2005), who argue that numerous studies that failed to find evidence of learning-by-exporting may have neglected a potentially important element of the process of productivity change: the investments made by firms to absorb and assimilate knowledge and expertise from foreign contacts. This means that exporting activity may have helped firms to become more innovative in their processes or products, which may impact productivity growth or firm survival in foreign markets in the long run. Accordingly, we alter the usual approach to study the learning from trade via firm total factor productivity growth. Instead, we define firm learning from trade as any introduction of a new product or a process following firm engagement in either import or export activities.

Regarding the second point, we argue that the sequencing of firm's learning from trade should go from (1) engagement in imports through (2) decision to start product or process innovation to (3) decision to start exporting and (4) to further product or process innovations induced by exports. We first present a simple theoretical setup which allows us to gain additional insight into the issues involved. In a sequence, we then use data for Spain and Slovenia combining usual firm-level accounting data with the data on innovation and trade flows and employ propensity-score based matching and average treatement effects in order to explore the exact sequencing between firm's engagement in trade and its learning from trade through innovation.

3 The Model

We present a simple model of the decision to engage in innovation and to start exporting by heterogeneous firms. Following Bustos (2007), we assume a single monopolistically competitive sector with differentiated products produced with a single factor of production (labor). We build on Melitz (2003) model assuming heterogeneous firms with respect to productivity, which is assigned exogenously to each firm. Firms face fixed exporting costs and, following Yeaple (2005) and Bustos (2007), firms also have the option of improving their productivity by paying an additional fixed cost of technological improvement.

3.1 Demand

As is commonplace in monopolistic competition models, we assume a representative consumer exhibits CES preferences over a continuum of varieties:

$$U = \left[\int_{i \epsilon I} q(i)^{\rho} di \right]^{1/\rho} \qquad 0 < \rho < 1 \tag{1}$$

where $q(i)$ is quantity of variety i and ρ is the substitution parameter. Consumers maximize their utility subject to the budget constraint, which yields demand for individual varieties

$$q(i) = \frac{E}{P} \left(\frac{p(i)}{P} \right)^{-\sigma} \qquad \text{where} \qquad \sigma = 1/(1-\rho) > 1 \tag{2}$$

where E is aggregate (country) income, $p(i)$ is the price of variety i and σ is the elasticity of substitution. The price index P is defined as

$$P = \left[\int_{i \epsilon I} p(i)^{1-\sigma} di \right]^{1/(1-\sigma)} \tag{3}$$

3.2 Production

On the production side, firms are monopolists in their respective varieties and their production technology features both marginal and fixed labor costs. Firms are heterogeneous in their productivity (indexed by ω) as they differ in marginal costs of production. In contrast to Melitz (2003), Yeaple (2005) and Bustos (2007) allow firms to upgrade their technology by paying an additional fixed cost, which reduces the marginal costs of production. In Yeaple and Bustos this represents a deterministic choice between two different technologies (low l and high h). Firms that do not invest in fact opt for low technology, while firms that choose to invest in an upgrade receive high technology. Our approach differs somewhat from here on as we propose that investing in a technology upgrade only increases the probability of a technological innovation occuring. In that sense, the investment is thought as research and development expenditure, which does not ensure innovation but only improves the likelihood that it occurs.

Additionally, we propose that firms, in addition to labor, also use intermediate inputs in the production of their final product. Here we employ a commonly used (Krugman, Venables, 1995; Venables, 1996) simplifying assumption that all final goods are also employed as intermediates in production[2]. Suppose the respective cost elasticities are μ for intermediate inputs and $1-\mu$ for labor. The total cost functions under each technology are therefore:

$$TC_l(\omega) = w^{1-\mu} P^{\mu} \left[f + \frac{q(\omega)}{\omega} \right] \tag{4}$$

$$TC_h(\omega) = w^{1-\mu} P^{\mu} \left[f\eta + \frac{q(\omega)}{\phi\gamma\omega + (1-\phi)\omega} \right] \tag{5}$$

$$\text{where } \varphi > 0 \text{ and } \gamma, \eta > 1$$

where ϕ is the probability of a succesful product or process innovation, γ measures the impact of higher technology on productivity[3] and η measures the additional cost of research and development. The expected productivity of R&D performing firms is therefore always higher than that

[2] Manufactures is using its own output as input.

[3] This effect could manifest itself as either product innovation leading to improved products (with higher markups), or process innovation leading to higher productivity of labor.

of firms that chose not to invest in R&D ensuring that the main results of the model do not differ from those in Bustos (2007). Whereas technology enchancing investment necessarily improves the technology of the investing firm in Bustos (2007), according to our approach it only improves the likelihood of a product or process innovation, but does not ensure succesful innovation.[4] ϕ is firm specific and can depend on absorptive capacity, number of previous innovation succeses, share of R&D employees, horizontal and vertical spillovers, importing and exporting status, share of R&D in sales, share of R&D workers in total employment, etc. Technology upgrading, though the same for all firms, benefits more productive fims more than less productive ones, which is evident from the profit condition for using technology h

$$\pi_h(\omega) > \pi_l(\omega) \iff \frac{1}{\sigma}E(P\rho)^{\sigma-1}\omega^{\sigma-1}\Big((\phi\gamma + (1-\phi))^{\sigma-1} - 1\Big) > w^{1-\mu}P^{\mu}f(\eta - 1) \tag{6}$$

3.3 Trade

As in Melitz (2003) firms face additional fixed costs of exporting f_e and variable iceberg transport costs τ in reaching the export markets. This ensures the usual productivity ordering of more productive firms into exports and less productive firms serving domestic market only.[5] The benefit of R&D investment is proportional to a firm's variable profits, which are higher for exporting firms than for non-exporters (see Bustos, 2007 for details). This implies that exporting status increases the profitability of technological adoption making firms more likely to invest in R&D if they are exporters. The underlying reason for the enchanced impact of technological upgrading on exporters is the larger platform in terms of production and sales which gets effected by the productivity improvement. On the other hand, higher productivity level of firms investing in R&D ensures that they are more likely to meet the exporting productivity requirement and start exporting. Investing in a technology upgrade therefore also improves the likelihood of becoming an exporter.

Finally, we also introduce importing into the model. As with exporting and innovation, we assume that firms face additional fixed cost of becoming importers. This can be interpreted as cost of searching for a suitable foreign supplier, cost of adjusting the imported intermediates for use in production, etc. Given the comparably higher costs of establishing exporting supply routes, we assume that the fixed cost of importing (f_{im}) is smaller than the fixed cost of exporting (f_e) On the other hand, importers' gain by utilizing cheaper intermediate inputs as the price index of the broader market (domestic and foreign market combined) has a lower price index than the domestic market alone. Assuming that home and foreign country share the same productivity distribution and elasticity of substitution, but the foreign market is m-times the size of the domestic market, then the combined price index becomes

$$P_T = \left[(1+m)\int\limits_{i\epsilon I} p(i)^{1-\sigma}di\right]^{1/(1-\sigma)}. \tag{7}$$

Since the $1/(1-\sigma)$ is always negative, P_T is smaller than P if $m > 0$. The resulting price index enables importers to benefit from lower marginal costs due to lower costs of intermediate goods

[4] Our assumption leads to the result that firms that do not invest in research and development will not innovate i.e. have zero chance of becoming succesful innovators.

[5] The productivity requirement for becoming an exporter is described by

$$\pi_l^{do}(\omega) < \pi_l^{ex}(\omega) \iff \tau^{1-\sigma}\frac{1}{\sigma}E(P\rho)^{\sigma-1}\omega^{\sigma-1} > w^{1-\mu}P^{\mu}f_e$$

as compared with non-importers. Taking into account the fixed cost of importing and assuming identical productivity distribution functions between the two countries, the size of the foreign market allows us to write the condition for becoming an importer (assuming low technology).

$$\pi_l^{im}(\omega) > \pi_l(\omega) \iff f + \frac{q(\omega)}{\omega} > (1+m)^{\frac{\mu}{1-\sigma}} \left[f + f_{im} + \frac{q(\omega)}{\omega} \right] \quad (8)$$

Firms with productivity exceeding the treshold defined by (8) will choose to start importing, whereby the benefits of being an importer increase with the increased productivity. Importing status therefore helps reduce the marginal cost of production for all firms that are able to bear the fixed cost of starting to import. Firms that become importers are subsequently likelier to upgrade their technology as reduced marginal costs lower the right-hand side of the condition for technology upgrading (6), which in turn reduces the productivity treshold for new innovators. Importing status, through lower intermediate costs, hence ensures that the cost of research and development is lower[6] Finally, a reduction in the price index will also reduce the fixed costs of starting to export for all perspective exporters by lowering the required productivity of new exporters. Importing status will hence improve both the probability of becoming an innovator as well as the probability of starting to export.

3.4 Implications of the model

This relatively simple theoretical framework generates a rich set of implications for studying the relationship between trade and innovation. The model suggests a clear sequencing between imports, exports and innovation. A firm with sufficiently high productivity to pay the cost of starting to import will benefit from the lower price of intermediates reducing the marginal cost of production and resulting either in increased productivity or a higher cost savings in production. As can be seen from (5), the increased productivity or lower share of cost of production increase the probability of a firm to invest a higher proportion of expenditures into R&D and hence increase the probability of successful innovations. At the same time, these innovations result in firm's technology upgrading and further improvements in productivity, which in turn increase the probability of a firm to start exporting. Of course, engagement in exports perpetually increases the probability of further investments into R&D, resulting in increased potential for innovations and productivity improvements.

This clear productivity ordering of importers, exporters and innovators, which is demonstrated by the empirical evidence (see Crepon et al., 1998; Cassiman and Golovko, 2007; Damijan et al., 2008, etc.), hence suggests that empirical studies searching for learning from trade should focus on the complete chain of links between imports, exports, innovation and productivity. While as deterministic in the initial stage as the Melitz (2003) and Constantini and Melitz (2007) setup in the sense that the the initial productivity is assigned to firms exogeneously by the luck of draw, our model allows for stochastic evolution of firm dynamics once a firm engages in international trade. As the fixed cost of starting to import is arguably lower than fixed cost of starting to export, it is obvious that a firm will first engage in imports than in export activities.[7] It is imports that allow firm first to learn the international markets as well as to benefit from lower price (higher quality) of intermediates and hence to shift the cost savings in production into the increased expenditures for R&D. From here on, firm dynamics is indeterminate as the firm may be lucky to turn the increased R&D expenditures into successful innovations or not. The same reasoning applies to firm's export engagement. Obviously, firm's engagement in trade may not lead to immediate productivity improvements, but may instead increase firm's ability to "learn" from trade by allowing for increased investments into R&D and hence for increased

[6] Alternatively, the benefits of importing can be interpreted in terms of higher quality of imported intermediate inputs for the same price as domestic (lower quality) inputs.

[7] Refer to Altomonte et al. (2008) for the pattern of trade of Hungarian firms.

probability of innovation. Innovation may the eventuelly result in productivity improvements. This is why in this paper we refer to learning from trade in the form of firm innovations instead of productivity improvements.

4 Data and sample characteristics

4.1 Data

The paper uses innovation survey data for Spanish manufacuring firms during the sample period 1991-1999 and Slovenian manufacturing firms from 1996-2002. The Spanish dataset from the Encuesta Sobre Estrategias Empresariales (ESEE) is an unbalanced sample of firms collected using direct interviewers with a questionnaire. For firms with less than 200 employees a random sample of survey participants is drawn ensuring the representativeness of the industrial and size categories[8]. The sample for large firms (above 200 employees) includes the whole population of large manufacturing firms. Our sample includes 16649 firm-year observations ranging from 1702 and 2059 observations per year between 1991 and 1999. This dataset (or a very similar one) has been used extensively by other authors[9]. In addition to accounting data on the surveyed firms, the ESEE also provides information on the innovative activity of manufacturing firms, imports, exports and foreign ownership. Most importantly from the perspective of this paper, we dispose with information on whether a firm has come out with product or process innovations, the number of these innovations, R&D expenditures, royalties paid and received etc.

[Insert Table 1 here]

The Slovenian dataset is based on firm-level data from Community Innovation Surveys (CIS1, CIS2, CIS3) and firm accounting data (AJPES) for the period 1996-2002. CIS represent an EU wide effort to assess innovation activity and its effects on firm performance. In Slovenia, Community innovation surveys are conducted every even year since 1996 by the Slovenian Statistical office (SORS). The surveys are carried out on a censored sample of manufacturing and non-manufacturing firms with no additional conditions put on actual R&D activity or size of these firms. Most importantly, the data gathered by the innovation surveys include, inter alia, information on product and process innovation of firms in two year periods as well as data on the determinants of innovation (employment and expenditure of research and development, etc.). In order to obtain additional insight into the causes and consequences of innovation, we merged CIS data with firm accounting data from annual financial statements as well as with data on firm exports flows.

[Insert Table 2 here]

4.2 Sample characteristics

A first glance at the properties of the two samples reveals that the sampled firms differ in their characteristics according to their exporting and importing status and innovating activity. In both the Spanish and Slovenian sample, firms that were active importers and exporters and have also innovated were found to have the highest labor productivity, while also being larger both in terms of sales as well as employment. On the other end of the spectrum, firms that engaged in neither international trade nor innovative activity were found to be the smallest and least

[8] The ESEE survey does not include firms with less than 10 employees.

[9] Gonzales, Jaumandreu et al. 2005; Salomon and Shaver, 2005, Cassiman and Martinez-Ros, 2007 and Cassiman and Golovko, 2007 among others.

productive. Although the Slovenian dataset is much larger in terms of firm-year observations, the Spanish dataset offers much more detailed infomation on innovation activity.[10]

[Insert Table 3 here]

An overview of the interaction between importing and exporting status and innovative success is given in the form of simple correlations in Table 3. Unsurprisingly, importing and exporting status are highly correlated with the respective correlation coefficents at 0.70 and 0.52 for Spanish and Slovenian data, respectively. Furthermore, both importing and exporting are correlated with innovation activity irrespective of whether product or process innovations are considered. About one quarter to one fifth of the variiation in the exporting and importing dummies can be explained by either product or process innovation dummies. This reinforces our initial belief that the importing, exporting status and innovative activity are related, but the direction of causality between them has yet to be discovered. A way to get some first insights into the possible causal relationships between them is to study the transitional probabilities between trade participation and innovation. We do this by looking into three hypothesized sequences between trade participation and inovation activity of firms. The first sequence shows probabilities of importing firms in $t-1$ to become innovators in period t. The second sequence shows probabilities of innovative firms in $t-1$ to start exporting in period t. And finally, the third sequence shows probabilities of exporters in $t-1$ to start innovating in period t.

[Insert Table 4 here]

Table 4 shows that in the sample of Spanish firms there is quite important mobility of firms between different trade participation and innovation states. In the first sequence, about 11 and 16 per cent of firms being importers but not innovators in $t-1$ become product or process innovators in t, respectively. The fraction of firms that are neither importers nor innovators in $t-1$ but start product or process innovating in t, is much lower, only about 7 and 12 per cent. This indicates that lagged importing experience may significantly affect firm's future ability to innovate. In the second sequence, good 12 per cent of non-exporting firms which started innovating in $t-1$ start exporting in t. This is to be compared to about 8 per cent of non-exporters in $t-1$ which start exporting in t. And in the third sequence, 13 and 20 per cent of non-innovating firms that started exporting in $t-1$ start product and process innovating in t, respectively. The fraction of first-time exporters in $t-1$ which do not become product or process innovators in t is only about 7 and 12 per cent, respectively. This again indicates that previous exporting experience may induce firm innovation activity in the future.

[Insert Table 5 here]

In case of Slovenia, this mobility of firms between different trade participation and innovation states is less pronounced. As demonstrated in Table 5, there is a slightly higher probability of firms being importers but not innovators in $t-1$ to become product or process innovators in t than without this importing experience. Similarly, firms starting to innovate in $t-1$ are marginally more likely to become exporters in t than non-innovating firms. In the third sequence, non-innovating firms that started exporting in t are not necessarily more likely to start product or process innovating in t than non-exporting firms.

[10] For example, we do not dispose with information on the number of product and process innovations in the Slovenian dataset.

5 Methodology

In order to get at the causal relationship between international trade (importing and exporting status) and innovation, we want to test whether importing status/exporting status enhances the probability of succesful innovation and vice-versa. We explore the direction of causality by allowing for the sequencing between trade and innovation in three stages. Firstly, we examine the impact of lagged importing status on the probability of becoming a first-time succesful innovator (product or process innovators) or becoming an exporter. Secondly, we test whether lagged first-time innovation status impacts the probability of becoming a first-time exporter in the current period. Finally, we explore the effect of first-time exporting status on the probability of becoming a first-time innovator. We employ matching techniques based on propensity scores to check whether there exist the proposed sequencing pattern between imports, exports and innovation.

The matching techniques enable the selection of a valid control group. The purpose of matching is to pair importing (first-time exporting and first-time innovating) firms on the basis of some observable variables with non-importers (non exporters, non-innovators). Given the variety of firm observables (productivity, size, ownership, industry and time effects) that could potentially serve as a basis for matching, one encounters the dimensionality problem. The problem of having too many possibilities for matching (too many dimensions) can be resolved by applying propensity score-matching (Rosenbaum and Rubin, 1983), which uses the probability of receiving a given treatment, conditional on the pre-entry characteristics of firms, to reduce the dimensionality problem (a single index hence replaces all of the pertinent observable firm characteristics).

The propensity score specification we use to describe the decision to import is given by

$$P(Imp_t = 1) = f(va\_emp_{t-1}, k\_emp_{t-1}, emp_{t-1}, fdi_{t-1}) \tag{9}$$

where Imp_t is an indicator of whether a firm is an importer at time t ($Imp_t = 1$) or not ($Imp_t = 0$). In this stage we only consider those importers (non-importers) that were not yet exporters or succesful innovators[11]. va_emp_{t-1} is the lagged value added per employee, k_emp_{t-1} is lagged capital per employee, emp_{t-1} is lagged size (in terms of employment) and fdi_{t-1} is the lagged foreign ownership status (if at least 10% of capital is foreign owned the variable assumes value 1, 0 otherwise).

The propensity score specification for decision to start innovating is similarly given by

$$P(Inov_t = 1) = f(RD/Sal_{t-1}, va\_emp_{t-1}, k\_emp_{t-1}, emp_{t-1}, fdi_{t-1}) \tag{10}$$

where $Inov_t$ is an indicator of whether a firm has succesfully innovated for the first time in period t ($Inov_t = 1$) or not ($Inov_t = 0$). RD/Sal_{t-1} is lagged R&D expenditures relative to firm sales, while the remaining variables are the same as above. Similarly as above, we only consider those innovating firms that were not yet exporters up to this point in time. Based on (9 and (10) we proceed to match importers with non-importers and innovators with non-innovators to see whether either lagged importing status or lagged succesful innovation has an impact on the likelihood of becoming and exporter. Firms with similar likelihoods of being importers (or innovators) are matched within the same year-sector space. Sectors are defined as NACE 2-digit industries, which may be too broad a definition of a sector, but going to a more dissagregated level would severely limit the number of year-sector observations and limit the scope for credible average treatment estimates. This specification satisfies the balancing property ensuring that the two cohorts do not differ substantially with respect to the regressors in respective blocks. We use nearest neighbour matching to find the most similar firms and analyze the effects of the treatment variable although regressions with other types of matching procedures (such as kernel

[11] Excluding firms that were already innovating and exporting will allow us to get a clearer picture of the direction of causality between importing, innovation and exporting.

and radius matching) have yielded very similar results.[12]
On the other hand, we test effect of exporting and importing status on the probability of becoming a succesful product or process innovator. For that purpose, we additionally specifiy the following propensity score specifications for exporting status

$$P(Exp_t = 1) = f(va\_emp_{t-1}, k\_emp_{t-1}, fdi_{t-1}) \tag{11}$$

where Exp_t is an indicator variable of first-time exporting status of the firm at time t. Firms that have become exporters for the first time in period t have a value of 1, non exporters 0. We explicitly differentiate between product and process innovators by running two separate specifications (one for first-time product and one for first-time process innovators). Again, the propensity score estimates from (9) and (11) are employed to match importers and non-importers and exporters with non-exporters to assess the impact of lagged exporting and importing status on the probability of becoming an innovator and vice versa. Instead of presenting the results separately for each industry-year pairing, we only show aggregate results for the entire sample with the averages weighted by the number of observations in a industry-year pairing.

In order to test whether the assumption of conditional independence is satisfied in our different specifications, we determine the reduction of median absolute standardized bias brought about by the use of matching[13] (Becker and Egger, 2007). Rosenbaum and Rubin (1985) suggest the remaining bias should not exceed 20 per cent. In our case the median absolute standardized bias in case of the propensity to import amounts to only 2.8% for the Spanish dataset (0.5% for the Slovenian dataset), while in case of the propensity to innovate (all innovation, product and process innovation separately) it equals 2.5% (2%) and, finally, in case of the propensity to start exporting to 17.5% (16%). In all three cases the remaining bias is well within the suggested bound of 20%. Overall, our matching procedures reduce the bias by about 66% as compared with the initial sample. Furthermore, a comparison of pseudo-R^2 of the propensity score estimation before and after matching reveals a significant reduction in the explanatory power of these estimates in all specifications and size classes. In all specifications the explanatory power is substantially reduced by at least 20%. This indicates that in the matched sample of treated and control units there is no longer any systematic difference in observables between the two cohorts of units, leading us to conclude that our matching procedure satisfies the balancing property and the conditional independence assumption is not violated.
Previous studies using these datasets for Spain and Slovenia have demonstrated that the results either for the decision to start exporting or the decision to start innovation are associated with the firm size. We therefore split our datasets into three subsamples according to the standard size classes. The first subsample consist of small firms with less than 50 employees. The second one comprises medium sized firms with number of employees between 50 and 200, while the third size class contains large firms with more than 200 employees. To ensure comparability over time, each firm is classified into a specific size class according to its average number of employees over the period. In what follows, we report the results separately for each size class.

In addition, the literature review has demonstrated that there might be non-linear relationship between trade participation and innovation impacted by firm's distance to the technology frontier. We therefore split our country datasets into five quintiles according to the level of firm productivity and run separate tests for the bottom (laggard firms) and the top quintile (front runners). The results are presented separately for each subsample.

[12] These results are not presented here for the sake of brevity.
[13] We calculate the median absolute standardized bias in the observables included in the selection specification between the treated firms and all control observations compared with the treated and matched control units.

6 Results

6.1 Accounting for firm size

Results of average treatment effect of the four status variables on the likelihood of either starting to innovate induced by the lagged import status, starting to export induced by firm's lagged import and innovation status as well as starting to innovate based on firm's lagged export status for the Spanish sample and Slovenian sample of firms are summarized in Table 6 for Spain and Table 7 for Slovenia. We present the outcome variables of the three sequences in a separate columns, while rows represent the treatment variable used in the particular matching estimation. The first two columns display results of the treatment effects of lagged importing status (imp_{t-1}) on the decision to start innovating separately for product ($start\_pd_t$) or process innovation ($start\_pc_t$), respectively. Third column presents results of the effect of lagged importing status (imp_{t-1}), product innovation (pd_start_{t-1}) and process innovation (pc_start_{t-1}) on the probability to start exporting. Finally, columns 4 and 5 show results of the treatment effects of lagged exporting status (exp_start_{t-1}) on the decision to start product innovation ($start\_pd_t$) or process innovation ($start\_pc_t$), respectively. All explanatory variables are lagged relative to the year of export entry or the year of succesful product or process innovation. Note that we assign a firm to have started innovation or exports in the period $t-1$ if this switch from non-innovation to innovation status and non-exporting to exporting status has occurred within the last four years. This is partly due to relatively small, data samples, but predominantly due to the fact that the change in status may take time before it affects firm's processes and performance.

[Insert Table 6 here]

Results of the nearest-neighbour matching procedure on the Spanish sample separated by size classes (Table 6) reveal that there is a clear impact of international involvement on succesful innovation, but that it is mainly valid for small and medium sized firms. Imports seems to matter for the probability of all firms to start either product or process innovations, whereby these probabilities increase with the firm size. Larger importing firms are more likely to start innovations. On the contrary, lagged importing status is shown to have a significant impact on the decision to start exporting only for a subsample of small firms. In the second stage, there is no conclusive evidence that firms that recently started innovation are more likely to start exporting in the future. In the third stage, lagged export status is shown to induce further process innovations in small firms and product innovations in medium-sized Spanish firms. For large firms, lagged exporting status seems to negatively affect further product or process innovations.

Results for Slovenian sample is presented in Table 7. Again, there is conclusive evidence in support of the effect of international trade on the likelihood of becoming an innovator, but as was the case with Spanish data, the effects are only significant for small and medium-sized firms.

[Insert Table 7 here]

For small Slovenian firms, importing status is, again, found to have a significant positive impact on the probability that firms will become first-time succesful innovators and exporters. In the second stage, there is no evidence that first-time innovators (product or process) in the past four years will effectively become new exporters.[14] This linkage from innovation to exports has been found significant only in the case of large firms, whereby previous product innovations may

[14] As a consequence of the fact that we only dispose with survey data for the even years between 1996 and 2002, the effect of the odd lags of innovation starters cannot be estimated.

positively affect probability to start exporting, and process innovations have a negative impact on the probability to export in the future.

In the third stage, small and medium sized firms which started exporting only recently are found to be more likely to introduce product or process innovations in the future. For larger firms these probabilities are likely to be negative, although not significant. One can explain this with the fact that a majority of large Slovenian firms are already engaged both in imports, exports as well as in innovation activities.[15] This leaves not much potential for switching either the trade or innovation status and any changes can be subject to time specific effects.

6.2 Accounting for technology frontier

Firms size was shown to have a significant impact on the relationship between importing status, exporting status and innovative activity. So far we have not accounted for other relevant firm characteristics that could affect the relationship, such as firm productivity. As shown by the large body of the empirical literature, firm's relative productivity or its distance from the relevant technological frontier can substantially alter its behaviour both in terms of when it chooses to enter foreign markets as well as wheter or not to import materials and capital goods. In addition, the productivity level can also be correlated with the firm's absorptive capacity which can affect the dynamics of both the adoption of technology and own innovation. As demonstrated by several empirical studies (Carlin et al, 2004; Aghion et al, 2006; Gorodnichenko et al, 2008), the firm's innovation activity may well depend upon its distance to the relevant technology frontier. In order to analyze the importance of firm relative productivity, we test the above relationships for both the productivity laggards and front-runners. We first estimate total factor productivity as a residual of

$$\ln(va_t) = \alpha + \beta_1 \ln(k_t) + \beta_2 \ln(l_t) + \varepsilon_t$$

where va_t represents valua added, k_t is capital and l_t is labor. We allow the coefficients β_1 and β_2 to vary across NACE 2-digit industries and estimate the equation separately by years. Based on the estimated total factor productivity we test the relationship between importing status, probability of becoming a new exporter and the probability of becoming a first-time innovator separately on industry-leaders and laggards. We define the front-running firms as those in the top quintile of the industry's productivity distribution, with the laggards being those in the bottom quintile. Table 8 presents the results of the relationships between importing, innovation and exporting for the respective cohorts of industry front-runners and laggards for Spanish firms

[Insert Table 8 here]

The estimates reveal notable differences between the cohorts of industry laggards and leaders in terms of productivity. We find that there is a statistically significant effect of lagged importing status on the probability of starting to innovate only for laggard firms while the effect is no longer significant for front runners. Similarly, only laggard importing firms experienced a significantly higher likelihood of becoming first-time exporters than their non-importing counterparts. Furthermore, productivity laggards also experience a significantly higher likelihood of becoming first-time exporters if they have successfully innovated for the first time in the previous period. Finally, lagged export-starter status does not improve the likelihood of becoming a first-time innovator neither for the laggards nor for the front runners.

[Insert Table9 here]

[15] Damijan and Kostevc (2006) show that the share of exporters among large firms in bigger, while Damijan et al (2006) demonstrate that large firms are 2-3 times more likely to conduct innovation activities.

The estimates for the Slovenian sample are presented in Table 9. Lagged importing status is shown to improve the likelihood of firms becoming first-time innovators for both productivity laggards and front-running firms. The only difference being that for the laggard firms imports is more likely to induce process than product innovations, and vice versa for the front runners. Imports is also found to increase the probability of both groups of firms to start exporting. This result replicates the results for the sample of small firms, which is a consequence of proportionately large share of smaller firms in both cohorts of leaders and laggards. There is some evidence in the productivity front-runners cohort that firms that started to process innovate in the previous period are significantly more likely to become new exporters, while, surprisingly, firms that started to product innovate are less likely to start exporting than non-innovators. Interestingly, frontier firms exhibit no statistically significant relationship between lagged export-starter status and the probability of becoming a successful innovator, while laggard firms among exporter starters are more likely to start process innovations (but not product innovations). This result is consistent with the results of Damijan et al (2008), which find that for small and medium sized firms exporting increases the probability of inducing process innovations, but not product innovations. For Slovenian firms therefore size seems to matter comparatively more than the distance to frontier to engage both in trade as well as in the innovation activities.

7 Conclusions

This paper explores the learning effects of firm's participation in trade. We argue that one should study both the import as well as the export engagement of firms in international firms as both may have important beneficial effects for firm performance. In addition, the learning effects of firm's participation in trade are studied through the channels of firm innovations. In line with Aw et al (2005) we believe that a firm may learn through its international contacts and demand - supply chains, which may in turn be reflected in its innovation efforts in terms of new products or new processes. These innovations, however, do not necessarily immediately translate into firm productivity improvements, but this learning from trade may impact productivity growth or firm survival in foreign markets in the long run. In this respect, we argue that it is important to study the sequencing of firm's participation in trade and consequent learning effects. This sequencing of firm's learning effects from trade should go from (1) engagement in imports through (2) decision to start product or process innovation to (3) decision to start exporting and (4) to further product or process innovations induced by exports.

We use microdata for Spain and Slovenia combining usual firm-level accounting data with information on innovation and trade flows and employ matching to explore the exact sequencing between firm's engagement in trade and its learning from trade through innovation. Our empirical excercises show remarkably similar results for both datasets. First, firm's importing status is shown to significantly impact its ability to start product or process innovations, which, however, do not necessarily affect firm's decision to start exporting. In the final stage, exporting is shown to boost further product and process innovations. Second, this sequencing of firm's learning effects from participation in trade seems to be most important for small and in part for medium-sized firms, while there are no conclusive results for large firms. And third, the sequencing of firm's learning effects from trade seems, at least for the samples of Slovenian firms, not to be affected by firms' distance from the relevant technology frontier. The estimates based on the sample of Spanish firms, on the other hand, reveal that internationalization benefits laggard firms more than those on the productivity frontier.

Our results indicate the importance of import links for smaller firms enabling them to learn both in terms of the production processes as well as in order to improve their product characteristics. This may help firms to dress up for the consequent entry to foreign markets with their products. This results are in line with the recent theoretical work by Constantini and Melitz (2007) trying to enrich existing models of international trade of heterogenous firms by allowing for firm's endogenous innovation, which may explain what makes some firms "better" and more suitable for their decision to start exporting. Previous learning from the engagement in imports might be the key for smaller firms, but as shown above, the whole sequencing chain is important in order to understand firm's learning effects from trade.

In terms of policy recommendations, this paper implies that government policies should focus on small and medium sized firms in order to promote both their internationalisation processes as well as their innovation activities. While large firms can either use their own assests or borrow assets in financial markets to bear the cost of financing trading and R&D activities, small and medium sized firms are more financially constrained. Government policies should hence assist small and medium sized firms with the special internationalisation funding scheme, which will provide them with targeted loans for either financing acquisition of new technology lines or starting starting new export deals. Another important government assistance scheme would be special training scheme for new exporters and provision of information on potential import and export partners. On the other side, targeted R&D subsidies and tax credits for R&D expenditures would substantially lower the cost of R&D activities of small and medium sized firms. Similarly, promotion of R&D cooperation between universities and businesses would also benefit more smaller firms, which have fewer contacts and less funds for this sort of activities.

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8 Tables to be included into text

Table 1: Characteristics of the Spanish sample in 1999 (mean values appart from the number of firms)

	innovating firms				non-innovating firms			
	exporters		non-exporters		exporters		non-exporters	
	imp=0	imp>0	imp=0	imp>0	imp=0	imp>0	imp=0	imp>0
VA_emp	5.61	1.40	2.91	1.59	4.09	1.53	4.21	3.24
K_emp	6470.4	16065.1	6004.0	11292.1	8834.1	15408.4	5583.2	7977.7
size (employment)	82.70	500.14	36.35	145.07	68.51	292.01	35.79	64.99
size (revenue)	1,590,971	20,013,278	496,569	4,957,993	1,916,835	11,064,972	569,853	1,700,946
number of firms	77	541	115	82	95	382	1,799	104
no. of prod. innov.	2.75	9.90	1.22	2.47	0	0	0	0
no. of proc. innov.	5.90	6.13	6.23	6.02	0	0	0	0

Note: VA_emp and K_emp in current Spanish pesetas

Source: ESEE, own claculations.

Table 2: Characteristics of the Slovenian sample in 2002 (mean values appart from the number of firms)

	innovating firms				non-innovating firms			
	exporters		non-exporters		exporters		non-exporters	
	imp=0	imp>0	imp=0	imp>0	imp=0	imp>0	imp=0	imp>0
VA_emp	9433.1	6353.4	4385.7	6926.3	3958.35	6509	3702.53	5063.65
K_emp	135,870	22,126	10,294	60,729	22904.3	34102.6	28019.2	33008.4
size (employment)	25	297.6	78.2	134.7	11	36.3	5.73	11.8
size (revenue)	637,842	5,374,671	4,784,621	2,843,532	244,942	1,008,699	95,836	237,900
number of firms	1	393	46	50	809	5,147	16,022	4,679

Note: VA_emp and K_emp in current Slovenian tolars (SIT)

Source: SORS, own calculations.

Table 3: Correlation between importing, exporting and innovation for Spain and Slovenia

Spanish sample						
	imp dum	exp dum	pd	pc	pd num	pc num
imp dum	1					
exp dum	0.7021*	1				
pd	0.2253*	0.2449*	1			
pc	0.2102*	0.2085*	0.3326*	1		
pd num	0.0590*	0.0685*	0.2177*	0.0699*	1	
pc num	0.2200*	0.2196*	0.3418*	0.9900*	0.0716*	1
Slovenian sample						
	imp dum	exp dum	pd	pc		
imp dum	1					
exp dum	0.5166*	1				
pd	0.2374*	0.2380*	1			
pc	0.2064*	0.2107*	0.7351*	1		

Note: * indicates statistical significance at 1%

Source: ESEE and SORS; own calculations.

Table 4: Transitional probabilities between trade participation and innovation for Spain, in per cent

	start to product innovate (t)		start to process innovate (t)	
import status ($t-1$)	0	1	0	1
0	92.8	7.2	87.9	12.1
1	89.1	**10.9**	83.7	**16.3**

	start to export (t)	
start to product innovate ($t-1$)	0	1
0	92.2	7.8
1	87.5	**12.5**
start to process innovate ($t-1$)	0	1
0	92.3	7.7
1	87.7	**12.3**

	start to product innovate (t)		start to process innovate (t)	
start to export ($t-1$)	0	1	0	1
0	92.9	7.1	87.7	12.3
1	86.5	**13.5**	79.7	**20.3**

Source: ESEE, own calculations.

Table 5: Transitional probabilities between trade participation and innovation for Slovenia, in per cent

	start to product innovate (t)		start to process innovate (t)	
import status ($t-1$)	0	1	0	1
0	98.3	1.7	98.6	1.4
1	98.1	**1.9**	98.1	**1.9**

	start to export (t)	
start to product innovate ($t-1$)	0	1
0	73.6	26.4
1	70.4	**28.6**
start to process innovate ($t-1$)	0	1
0	73.5	26.5
1	70.4	**29.6**

	start to product innovate (t)		start to process innovate (t)	
start to export ($t-1$)	0	1	0	1
0	98.2	1.8	97.7	2.3
1	98.4	**1.6**	98.2	**1.8**

Source: SORS, own calculations.

Table 6: Summary of the results of nearest neighbor matching on the causal relationship between trade participation and innovation for Spain, by size classes

	small firms ($emp \leq 50$)		
	$P(\text{start pd}_t)$	$P(\text{start pc}_t)$	$P(\text{start exp}_t)$
imp_start_1	0.026*	0.024	0.027***
pd_start_1			0.057
pc_start_1			-0.003
exp_start_1	0.026	0.112***	
	medium firms ($50 < emp \leq 200$)		
	$P(\text{start pd}_t)$	$P(\text{start pc}_t)$	$P(\text{start exp}_t)$
imp_start_1	0.063**	0.118***	0.062
pd_start_1			0.041
pc_start_1			0.073
exp_start_1	0.129***	0.090	
	large firms ($200 < emp$)		
	$P(\text{start pd}_t)$	$P(\text{start pc}_t)$	$P(\text{start exp}_t)$
imp_start_1	0.101**	0.087*	0.033
pd_start_1			0.077
pc_start_1			0.016
exp_start_1	-0.047	-0.252*	

Note: *,** ,*** denote statistical significance at the 10%, 5% and 1%.
exp, imp, pd and pc indicate exports, imports, product and process innovation, respectively.
Source: ESEE, own calculations.

Table 7: Summary of the results of nearest neighbor matching on the causal relationship between trade participation and innovation for Slovenia, by size classes

	small firms ($emp \leq 50$)		
	$P(\text{start pd}_t)$	$P(\text{start pc}_t)$	$P(\text{start exp}_t)$
imp_start_1	0.011***	0.012***	0.129***
pd_start_1			-0.040
pc_start_1			0.068
exp_start_1	0.009***	0.013***	
	medium firms ($50 < emp \leq 200$)		
	$P(\text{start pd}_t)$	$P(\text{start pc}_t)$	$P(\text{start exp}_t)$
imp_start_1	0.018	0.020	0.093***
pd_start_1			-0.055
pc_start_1			-0.164
exp_start_1	0.031***	0.001	
	large firms ($200 < emp$)		
	$P(\text{start pd}_t)$	$P(\text{start pc}_t)$	$P(\text{start exp}_t)$
imp_start_1	-0.045	0.019	0.226***
pd_start_1			0.500***
pc_start_1			-0.675***
exp_start_1	-0.048	-0.080	

Note: *,** ,*** denote statistical significance at the 10%, 5% and 1%.
exp, imp, pd and pc indicate exports, imports, product and process innovation, respectively.
Source: SORS, own calculations.

Table 8: Summary of the results of nearest neighbor matching on the causal relationship between trade participation and innovation for Spain, by productivity classes

	laggard firms (1st VA/L quintile)		
	P(start pd$_t$)	P(start pc$_t$)	P(start exp$_t$)
imp_start_1	0.061**	0.059*	0.093***
pd_start_1			0.078
pc_start_1			0.067**
exp_start_1	0.070	0.082	
	front-runners (5th VA/L quintile)		
	P(start pd$_t$)	P(start pc$_t$)	P(start exp$_t$)
imp_start_1	0.058	0.058	0.039
pd_start_1			0.131
pc_start_1			0.077
exp_start_1	-0.067	-0.039	

Note: *,** ,*** denote statistical significance at the 10%, 5% and 1%.
exp, imp, pd and pc indicate exports, imports, product and process innovation, respectively.
Source: ESEE, own calculations.

Table 9: Summary of the results of nearest neighbor matching on the causal relationship between trade participation and innovation for Slovenia, by productivity classes

	laggard firms (1st VA/L quintile)		
	P(start pd$_t$)	P(start pc$_t$)	P(start exp$_t$)
imp_start_1	0.008***	0.015***	0.111***
pd_start_1			-
pc_start_1			-
exp_start_1	0.000	0.027***	
	front-runners (5th VA/L quintile)		
	P(start pd$_t$)	P(start pc$_t$)	P(start exp$_t$)
imp_start_1	0.017***	0.010***	0.146***
pd_start_1			-0.156**
pc_start_1			0.140***
exp_start_1	-0.005	-0.003	

Note: *,** ,*** denote statistical significance at the 10%, 5% and 1%.
exp, imp, pd and pc indicate exports, imports, product and process innovation, respectively.
Source: SORS, own calculations.

Table 10: Summary of the results of nearest neighbor matching on the causal relationship between trade participation and innovation for Spain, by TFP productivity classes

	laggard firms (1*st* TFP quintile)				
	P(start pd_t)	P(start pc_t)	P(start exp_t)	P(start pd_t)	P(start pc_t)
imp_start_1	0.015***	0.010***	0.117***		
exp_start_1				0.029***	0.017
pd_start_1			-		
pc_start_1			0.500***		
	front-runners (5*th* TFP quintile)				
	P(start pd_t)	P(start pc_t)	P(start exp_t)	P(start pd_t)	P(start pc_t)
imp_start_1	0.008	-0.003	0.144***		
exp_start_1				-0.004	-0.015***
pd_start_1			-		
pc_start_1			-0.112		

Note: *,** ,*** denote statistical significance at the 10%, 5% and 1%.

exp, imp, pd and pc indicate exports, imports, product and process innovation, respectively.

Source: ESEE, own calculations.