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Innovation and the Creative Destruction of Trade: A Study of the Intensive and Extensive Margins of Trade for French Firms

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Abstract

Our study of French exporters examines the causal relationship between innovation and extensive and intensive margins of trade using a propensity score matching and difference-in-differences approach. Results show innovation has a positive impact on total exports driven primarily through the intensive margin. To understand the absence of an extensive margin effect, we show new and terminated product-country transactions increase at similar rates in the year of innovation for the treated and control groups but net trade creation for innovators outstrips that of non-innovators in the following two years implying firms need to innovate in order to survive in export markets.

JEL classification: D22, D24, F14, F23, F61, O31, O33

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1 Introduction

In an increasingly globalized world, firms and countries are in a continuous battle to maintain and improve their levels of productivity and competitiveness. Two important drivers of firm performance are acknowledged to be technological development through endogenous innovation and international trade. However, less well understood, and of particular importance for mature developed economies, is the relationship between innovation and exporting. Success in innovation is often considered crucial for developed countries to maintain or to re-establish a competitive advantage in high quality, high value-added manufacturing over newly industrialised countries. Given these concerns there is a growing theoretical literature that explains the productivity effect of innovation through the complementary effects of trade and R&D (Eaton and Kortum 2002, Cassiman et al. 2010, Aw et al. 2011, Van Long et al. 2011 and Hallak and Sivadasan 2013).

Attempts to formalise the link between the decision to undertake research and development (R&D) and future export performance treats the evolution of productivity as endogenous and determined by the innovation decision (Costantini and Melitz 2008 and Atkeson and Burstein 2010). In other theoretical studies, R&D expenditure is introduced as a choice variable in an effort to shed light on the positive correlation between exporting and productivity (Aw et al. 2011, Bustos 2011 and Aghion et al. 2018). These studies build on the notion that R&D expenditure and export decisions are interdependent and that both activities endogenously influence future productivity highlighting the self-selection of the most productive firms into both R&D expenditure and exporting.[1]

[1] Other research considers the introduction of R&D into existing trade models to generate predictions of the impact of trade liberalisation on productivity growth (e.g. Lileeva and Trefler 2010 and Boler et al. 2015). These models demonstrate how trade liberalisation changes the rate of return on R&D and results in endogenous productivity

The purpose of this paper is to provide a greater understanding of the mechanisms by which the decision of a firm to innovate affects exports and by extension provides insights into a firm's ability to survive in increasingly competitive global markets. More specifically, the contribution of the paper is two-fold. First, we examine the impact of innovation on a firm's traditional measures of intensive and extensive margins of trade. Second, for the first time to the best of our knowledge, we examine the effect of innovation on net trade creation by comparing the value of new trade transactions and those transactions that are terminated. Looking at the impact of innovation on the creation and destruction of traded varieties (country-product pairs) means we are able to shed light on the process by which innovation induces churn in exported product-country transactions and how this can explain why previous studies have only found limited impact of innovation on the extensive margins (see e.g. Damijan et al. 2010, Becker and Egger 2013 and Lo Turco and Maggioni 2015).

Our analysis is based on a panel of over 27,000 French manufacturing firms for the period 1999 to 2007 and is the result of the merging of four different datasets, including R&D activities from the French Ministry of Education and Research and transaction-level export data from the French Customs agency. The richness of our data means that we have information on the innovation activities of a large number of French firms over a considerable period of time.

Our empirical strategy follows Lechner (2002) and Becker and Egger (2013) and employs a propensity score matching (PSM) and difference-in-difference (DiD) analysis using different measures of innovation as multiple

gains.

treatments. This approach allows us to control for confounding factors that affect innovators and non-innovators (e.g. policies that affect only certain sectors), selection on observables by controlling for firm characteristics, and unobservable time invariant firm heterogeneity (Blundell and Dias 2009). In a PSM context, our relatively large sample size and long time period mean, for the first time, we are able to focus on exporting firms that switch from doing no innovation related activities to those that start to engage in the innovation process. This means we are able to investigate the effect of innovation on future export performance without concern for the impact of previous innovation or accumulated innovation knowledge on exports. By restricting our sample to existing exporters we are able to examine how innovation increases or decreases future exports. While previous export experience may be the cause of innovation, because all firms in the sample are exporters, it means we are able to estimate the impact of innovation on the intensive margin which would not be possible for new export starters where according to our measurement of the intensive margin, the value would be zero by definition. In addition, we mitigate concerns of reverse causality since all of our firms are exporters and the matching process controls for previous export intensity and other firm characteristics.

A further contribution is our measurement of innovation. Our data allow us to consider innovation both as an input and as an output measure. It can be argued that measures of innovation output (product and process innovation) more accurately capture the link between innovation and export performance by providing a direct channel by which the commercial adoption of a particular innovation affects exports. This allows us to capture, to a certain extent, the successful output of the innovation process (Kleinknecht et al. 2002). We are also able to measure product and process innovation separately as combining them is rather crude given the differences in the underlying economic mechanisms (Klepper 1996). Crucially, the introduction of new products and processes can be a disruptive process of transformation for a manufacturing firm. As Isogawa et al. (2012) point out, the development of new processes or products may temporarily reduce the value of domestic and foreign sales as a result of the costs of adaptation, cannibalisation of sales of older varieties of a product or changes to the production process, and is often used as an explanation for a delayed effect of innovation on total sales. Likewise, if a product is only new to a firm but not to the market then the company may have to lower prices in the short term to gain market share impacting the intensive margin.[2]

However, a drawback of using output measures of R&D is that the reporting of product and process innovation includes a degree of subjectivity. Hence, we also include total R&D expenditure (an input measure). In addition to not being subjective, not accounting for total R&D expenditure may underestimate the overall effect of innovation on exports as R&D expenditure should improve a firms' stock of knowledge and human capital even if it does not result in the introduction of a new innovation (Mohnen and Hall 2013).[3]

While theoretical predictions on how innovation may affect export margins are limited, there are a number of possible mechanisms by which we might expect innovation to influence export behavior and why innovation could lead to either an increase or decrease in exports, driven by either changes in the intensive or extensive export margins. In terms of the intensive margin that captures the value of existing country-product export

[2] Definitions of product and process innovation are provided in the data section.

[3] Studies that use firm level surveys to capture innovation outputs include Wakelin (1998), Kleinknecht et al. (2002), Cassiman and Golovko (2007), Chen (2013) and Becker and Egger (2013) while studies that use R&D expenditure as a proxy for innovation includes Braunerhjelm (1996) and Basile (2001).

shipments, the development of a new variety of an existing product, for example of a higher quality or more carefully tailored to local tastes (perhaps taking into account regional heterogeneity within a country), may deepen an existing trade relationship.

However, this process may lead the firm to reduce its exports of the previous version of the product to that country or to reduce the exports of other legacy products to the same country (cannibalization effect). In both cases they would negatively impact the intensive margin (if the value of exports of the new variety are outweighed by the reduced exports of other previously traded varieties to the same country). The result is that innovation can be considered, by its nature, a force of "creative destruction" with the introduction of new products often replacing previous versions of an existing product or other similar related products. This, in turn, may open up new markets and hence churns transactions to other markets as firms seek to maximise profits, increase market share and ultimately survive in an increasingly competitive environment (Schumpeter 1942).

In terms of the extensive margins, a similar mechanism may play out whereby innovation leads to the introduction of a new variety of an existing product that may be aimed at a new foreign market, such that the country extensive margin increases following innovation. However, it might be that the new market is a high margin developed country and that the firm uses expansion to this new market as a reason to exit high volume, low margin exports to low income countries. As before, the overall effect is ambiguous. Innovation may result in firms reducing exports of legacy products to a range of countries leading to a reduction in both extensive margins. Alongside the channels by which innovation can affect exporting is the notion that firms will often start small (experiment) when exporting a new product and then grow these over time with low volume exports of new products potentially replacing large export volumes for legacy products which are then wound down either slowly or sometimes abruptly (Albornoz et al. 2012). Which of these channels holds for the case of France in ultimately an empirical question and is the focus of this paper.

A brief review of the relatively scarce empirical literature shows that, methodologically, a small number of papers take a similar approach to our own. For example, Becker and Egger (2013) also use a PSM approach with multiple treatments using German firm level data over 3 years with one year of innovation data and find a strong positive effect of product innovation on the propensity to export. A similar approach by Lo Turco and Maggioni (2015), also with one year of innovation data, finds that innovation has a positive effect on export participation but not necessarily on entry into new export markets. Likewise, Damijan et al. (2010) also find that there is no evidence that innovation has an impact on firms entering new export markets.[4]

Hence, the empirical evidence is not conclusive. Although innovation appears to increase the probability of exporting, there is little research on how innovation impacts existing exporters and whether any increase in ex-

[4]Studies that take a more traditional econometric approach include Iacovone and Javorcik (2012) who show that firms anticipating future trade liberalisation invested in quality upgrading of products targeted at export markets and Criscuolo et al. (2010) who show a positive correlation between innovation and internationalisation. Other studies to find a positive relationship between R&D and exporting include Bleaney and Wakelin (2002), Roper and Love (2002) and Harris and Li (2009), Cassiman et al. (2010) and Cassiman and Golovko (2011). In contrast, Ganotakis and Love (2011) find that, conditional upon entering export markets, innovation does not result in an increase in export intensity, a finding shared with Harris and Li (2009). Finally, Isogawa et al. (2012) show that the introduction of a new product reduces sales of existing products in the short term but for new-to-market innovation they find larger sales and less cannibalisation, explaining why innovation might have a mixed effect on exports especially in the short term.

ports is driven by the intensive or extensive margins.

To briefly summarise our results, we find that different trade margins respond in different ways to innovation. In general we find that relative to the control group of non-innovators, R&D expenditure positively and significantly impacts total exports in the three years following the initial investment, driven primarily by maintaining the value of existing export transactions (intensive margin). Although we find a relative higher number of countries served two years after innovation compared to the control group, we find little evidence that total exports are driven by exporting either new products or by serving more countries (the extensive margins).

To understand the lack of evidence on the extensive margin we disentangle changes in exports into new transactions and terminated transactions. Our results show that the delayed effect of innovation on total exports is due to the value of net trade (new transactions minus terminated transactions) being similar for the control group relative to the treated group of firms. However, after two years, the difference in net trade creation between the treated and control groups becomes positive and significant, consistent with a "creative destruction" mechanism. In particular, by innovating and replacing obsolete products with new ones, innovating exporters are able to maintain their market shares in foreign markets while non-innovators see their exports falling. Our results suggest that French firms need to innovate to effectively stand still and that a failure to do so can have a significant and negative impact on exports.

The reminder of the paper is structured as follows. Section 2 presents the data and descriptive statistics. Section 3 describes our methodological approach. Results are discussed in section 4 and section 5 concludes.

2 Data Description

The data are constructed from the merger of four datasets on French manufacturing firms for the period 1999 to 2007. Firms' characteristics are obtained from the French Business Survey (FBS) completed by the National Institute of Statistics and Economic Studies (INSEE). This data provides detailed balance sheet information for French firms with more than 20 employees. Firm characteristics include total output, domestic and foreign sales, number of employees, salaries paid, cost of intermediate inputs, capital stock and investments in both tangible and intangible assets. The FBS data is then merged with the INSEE survey of financial relationships between enterprises (LIFI) which includes information on foreign ownership and whether a firm is affiliated to a French or a foreign group. In a third stage, we combine the firm characteristic data with firm-transaction-level export data collected by the French Customs Agency which provides 8-digit-level product codes, the value and volume of manufacturing exports and information on export destinations.[5]

The benefits of studying France are that, as well as being the second largest exporter in the EU after Germany (10.2% of total extra-EU exports), it also devotes considerable resources to R&D activities (approximately €48 billion in 2014 which represents 2.26% of GDP) and ranks

[5]Information is available for all transactions with a value exceeding € 100,000 for trade within the EU or exceeding € 1,000 for trade outside of the EU. The data covers more than 90% of French total exports of manufactured goods. During our period of analysis the threshold for intra-EU exports was changed twice. Until 2001 the value was € 38,000 which was then increased to € 100,000 and increased again after 2006 to € 150,000. For extra-EU exports the threshold remained unchanged. Mayer and Ottaviano (2007) point out that small exporters account for only a small share of total exports so these threshold changes should not adversely affect our results.

France second in the EU for total investment in R&D and sixth as a share of GDP. In addition, at least 55% of R&D expenditure is carried out by the private sector and in 2014 amounted to around €31 billion and employing 1.5% of the national total labour force.[6] Moreover, as Emlinger et al. (2019) point out, the market share of French exports has fallen significantly between 1999 and 2017.

To measure innovation we rely on the R&D Inquiry collected by the French Ministry of Education and Research. The data is based on a sample of over 7,000 firms that perform R&D activities and invest more than €350,000 per year in innovation plus a sample of those companies that undertake R&D but spend below the €350,000 threshold.[7] The data report the overall internal and external resources dedicated to R&D, the number of employees working in the R&D department, public funds received from the government and other public institutions, the number of patents held by the company and two indicators of innovation output that specify whether a firm has introduced a product or a process innovation in any given year. More specifically, product innovation is the introduction of a product that is improved in either its use or characteristics. These can include changes to technical specification, materials or functional use including new uses for existing products. The OECD (2009) classifies new products as those that are "new to the firm" and those that are "new to the market" with

[6]Figures are from the "Statistics on Research and Development" dataset and the "Intellectual Property Rights" database accessible at http://ec.ueopa.eu/data/database).

[7]The survey consists of four different strata. Three are exhaustive and form the principle component of the survey. The survey addresses a general questionnaire to all firms with an internal R&D expenditure above €2 million, and a simplified short questionnaire to all French firms investing more than €350,000, or to all the firms which have been included in the survey sample for the first time. In addition, a fourth strata of the survey is composed of a sample of remaining companies that dedicate fewer resources to R&D. The sample of the fourth strata is renewed every year, keeping half of the previous year sample and including as a second half R&D active firms that were not included in the previous year.

the latter likely to have a more dramatic impact through a temporary market power effect (Petrin 2002). In contrast, process innovation reflects the introduction of a new method of production or delivery (equipment or software). The expectation is that there will be cost per unit of production savings or improved delivery methods for existing products.[8]

Given that the R&D Inquiry is not exhaustive, after merging the four datasets, we remove observations that report positive investments in intangible assets, which include investments in R&D, in the FBS data but are not present in the R&D Inquiry dataset. We therefore consider, that firms in the FBS survey that report no investment in intangible assets and are also not included in the R&D Inquiry to be not engaged in the innovation process.[9] All the monetary values are expressed in Euros and have been deflated using OECD production price indexes at the industry-level for France using the year 2000 as the baseline.[10] After cleaning, our final sample consists of an unbalanced panel of almost 27,791 French firms, 16,790 of which are exporters with information on the number of products each firm exported, destinations served and the value of each shipment. Of our 27,791 firms, 3,854 undertake some form of innovation and the majority of these (3,666) also export. Definitions of all our variables can be found in Table A1 of the appendix.

[8]The exact wording of the questionnaire is as follows. Product innovation: Did your company introduce to the market in year t products or services that are technologically new or improved as a result of R&D activity. For process innovation: Did your company implement in year t processes that are new or improved as a result of R&D activity.

[9]We drop almost 19,000 observations that correspond to almost 9% of the merged dataset. However, removing these observations have no effects on the distribution of variables in the data. We also remove from our sample all the inconsistent observations and coding errors such as missing or incomplete data, negative values for total employment or average salary or when we have conflicting information across the different datasets.

[10]The data for the OECD production price indices can be found at https://stats.oecd.org/Index.aspx?DataSetCode=STAN08BIS.

Table 1 presents descriptives for a number of firm characteristics making the distinction between exporters and non-exporters for all the firms in our sample and for the smaller sub-sample of innovators. A firm is included in the innovator sample if it has engaged in the innovation process for at least one year of the sample.

[Table 1 about here]

Comparing the top and bottom panels of Table 1, the final column in the innovator sample shows that innovators are larger in terms of employment, pay higher average salaries, are more productive, have higher total sales (almost four times larger) and tend to invest more in fixed capital.[11] Innovators also have a higher share of exports in total sales (32.95% compared to 14.19% for all firms). Making the distinction between exporters and non-exporters, the top panel shows that, as expected, exporters are larger, more productive, invest more and pay average higher salaries than non-exporters. Comparing exporters and non-exporters within the sub-sample of innovators the results are even more striking. Our results are consistent with the idea that productive firms self-select into exporting and innovating activities (Aw et al. 2011 and Bustos 2011). However, it is worth noting that non-exporting innovators appear to have a higher R&D intensity than exporters when measured as the ratio of R&D expenditure over total sales, perhaps driven by large French state-owned groups which

[11] We follow the De Loecker (2007) approach to calculate TFP which is an extension of the standard Olley and Pakes (1996) methodology taking into account the heterogeneity in terms of productivity between exporters and non-exporters and between innovators and non-innovators. In our TFP estimations we use value added as a proxy for output, including in the estimation total employment as a measure for labor, the total costs of intermediate inputs as costs of production, an export dummy equal to 1 for exporters or 0 otherwise, and total investment in tangible and intangible assets such as R&D. Following the ISGEP (2008) approach, once estimated and logged, we remove the top and bottom percentiles without any significant loss of observations in order to mitigate the effect of outliers on our analysis. The methodology and results for our TFP calculations are available from the authors upon request.

operate in high-technology sectors but are oriented towards the domestic market (e.g. the nuclear sector, transport and infrastructure equipment, microelectronics, recycling, processed food and defence).

When we examine trends over time we find that total exports for firms in our sample grew from €134.2 billion in 1999 to €161.6 billion Euros in 2007. In the sub-sample of innovating firms, total exports increased from €80 billion in 1999 to €99.6 in 2007. However, when we examine trends at the firm level we find that, over the time period between 1999 and 2007, the average exporter in our sample experienced limited growth in total exports (from €14.58 million to €14.98 million). The extensive margins of the average exporter in our sample appear to have marginally improved over the period. In 1999, French firms exported 17 products and served 15 different destinations on average. By the end of the period, the average number of exported products was 17.32 and the average number of destinations was 16.17. However, the same cannot be said for French innovator-exporters who experienced a small decrease in both the number of destinations served (from 34 in 1999 to 32 in 2007) and the number of products exported (from 38 in 1999 to 35.5 in 1999). Moreover, while on average innovators export much more than non-innovators, the average total exports per innovating firm in our sample declined from €60.9 million in 1999 to €53.7 million in 2007. The increase in total exports that we observe seems to be driven by a rise in the number of exporters in our sample; from 14,448 in 1999 to 14,918 in 2007 and the sub-sample of innovating exporters from 1,362 in 1999 to 1,895 in 2007. The decline in the average total exports at the firm level in the sample of innovator-exporters seems driven by the entry of relatively smaller firms into this sample with the average size of an innovator exporter falling from 621 employees in 1999 to 462.6 in 2007.[12]

[12]In unreported summary statistics, when we consider individual sectors we find that

3 Methodology

A significant hurdle to the identification of a causal relationship between innovation and exports is the possibility of confounding factors that affect both innovators and non-innovators. This could include sector specific policies or shocks of a different nature. Our empirical strategy for identifying the causal link between innovation and export performance is to take a propensity score matching (PSM) and difference-in-differences (DiD) approach with multiple treatments (Lechner 2002 and Leuven and Sianesi 2003). Such a strategy allows us to compare the export performance of firms before and after they start innovating and to compare the results to a control group of comparable firms that continue to be non-innovators. The construction of a valid control group based on the observable differences between innovators and non-innovators means that our matching approach controls as best as we can for selection on observable and unobservable time-invariant firm heterogeneity.

The first stage is to define a set of endogenous innovation "treatments" that we call a. Innovation is considered to be an incremental process in which firms, conditional on an initial expenditure on R&D, successfully introduce a product innovation, a process innovation or both at time t. We

the majority of exports and R&D expenditures are driven by a relatively small number of industries. For example, the computers and ITC equipment sector has the highest intensity both in terms of R&D and exports, followed by optical and precision instruments, electrical machinery, chemicals and transport equipment. Not surprisingly, the motor vehicle industry also exhibits high levels of exports and innovation although production is concentrated among a small number of firms. Descriptives at the industry level are available from the authors upon request. See Bricongne et al. (2011) for a detailed description of the dynamics of French firm exports between 2000 and 2009 where they also distinguish between the intensive and extensive margins of trade and show that over this period the majority of the increase in exports could be explained by an increase in the intensive margin.

therefore analyse four different treatments. The first treatment is when a firm has positive R&D expenditure for the first time ($R\&D$), at some point after the start of our sample period, without introducing any product or process innovation at the same time. We then consider two different treatments for when a firm separately introduces a product innovation (Pd) or a process innovation (Pc). Finally, a fourth treatment is considered when a firm successfully introduces both a product and a process innovation in the same year ($PdPc$). Thus, our categorical variable a can take a value equal to 0 if a firm does not innovate in time t and $R\&D$, Pd, Pc or $PdPc$ if it performs one of the innovation treatments for the first time ($a = 0; R\&D; Pd; Pc; PdPc$) in a given year.

Therefore, treatment $a = 0$ refers to the control group of non-innovators, firms that do not invest in R&D or introduce innovations at any time during the sample period. Treatment $a = R\&D$ refers to those firms that start investing in R&D at time t but do not introduce product or process innovation at time t. Successful innovation is conditional on R&D expenditure, hence firms that introduce new innovations at time t ($a = Pd; Pc; PdPc$) have invested into R&D at and/or prior to time t. Firms that switch into innovation ($a = Pd; Pc; PdPc$) are not necessarily switchers into R&D since they could have always been engaged in R&D, within our time period, or started investing in R&D in a previous year. In a similar way, firms that switch into R&D in a given year ($a = R\&D$) may experience one of the 3 others positive treatments ($a = Pd; Pc; PdPc$) in a later year if the initial R&D investment led to the successful introduction of product innovation, process innovation, or both.

To accurately identify each treatment, we first drop all firms which are innovators but do not switch into any of our four treatments. That is to say we drop continuous innovators.[13] We then rescale the time period so that $t = 0$ is the year in which a firm first performs one of the treatments or as the median year in the case of non-innovators. Based on the observations at $t = 0$, we then measure the change, relative to $t - 1$, in export performance over the following three years.[14] We restrict the sample to firms that were exporters in $t - 1$, this allows us to analyse the effect of innovation on the intensive margins of exports and on net trade creation. Restricting the sample to existing exporters has also the advantage of reducing reverse causality concerns.[15]

Our analysis examines the average treatment effect on the treated (ATT) for each of our treatment groups. In other words, to estimate the difference in export performance between firms which have implemented one of the innovative treatments and similar (matched) firms which instead remain innovation inactive. We define y_{it} as firm i's export performance at time t and $y_{i(t+n)}$ as the export performance n periods later. The export performance variable y represents the different margins of trade: total exports; the total value, at each time period, of the existing set of transactions (product-country pair) in period $t - 1$ (intensive margin); the number of exported products; and the number of destinations (extensive margins). To understand our extensive margin results we further disentangle a firm's exports into new transactions and the termination of existing product-country transactions which gives us a measure of net trade creation. New transac-

[13] For example, a firm that innovates at the start of the sample and does not switch into treatments two, three or four is dropped.

[14] As part of the matching procedure, after identifying a treated firm at $t = 0$, we drop the subsequent observations of the same firm so that a firm cannot be matched with itself or be erroneously included in the control group after being treated.

[15] This restriction reduces our sample by almost 6,000 observations but only 103 of these correspond to treated firms. Therefore, restricting the sample to existing exporters has the further advantage of increasing the similarity between the sub-samples of treated and control firms.

tions are measured as the value, in each time period, of transactions that were not part of the export portfolio of the firm at time $t-1$. Terminated transactions are measured as the value at time $t-1$ of country-pair transactions that are no longer observed in each time period.[16] The net trade outcome is measured as the log difference between new and terminated transactions. The causal effect of innovative activities on the export performance of firm i at time $t+n$ is, therefore identified as the difference between:

$$y^{a}_{i(t+n)} - y^{0}_{i(t+n)} \tag{1}$$

where the subscripts denote the innovation treatments a undertaken by firm i at time t or 0 for firms who did not innovate during our sample period. Thus, $y^{0}_{i(t+n)}$ represents the export performance of firm i at time $t+n$ if it did not perform any of the four innovation treatments at time t. Remember we are interested in identifying the differences in export performance after a firm starts innovating. Hence, we can express the average effect on export performance that new innovators would have experienced if they had not performed any innovation activity as:

$$\tau^{a,0}_{ATT} = E\left(y^{a}_{i(t+n)} - y^{0}_{i(t+n)} \mid S_{it} = a\right) = E\left(y^{a}_{i(t+n)} \mid S_{it} = a\right) - E\left(y^{0}_{i(t+n)} \mid S_{it} = a\right) \tag{2}$$

where $\tau^{a,0}$ represents the expected effect on outcome y of treatment a in the post-treatment period, relative to the effect of no treatment 0 for the same firm. We are interested in the average treatment effect for each of the treatments a, that is, the difference in the outcome a firm would have experienced if it had not performed treatment a. The prob-

[16] The terminated transaction variable is cumulative over the three year period between t and $t+3$.

lem is that only one of the two possible outcomes in the previous equation is observable, whether the firm decides to perform an innovating activity or not, while the counter-factual for the same firm is not observed. Since $E\left(y^0_{i(t+n)} \mid S_{it} = a\right)$ is not observable, we construct a control group by considering instead the effect of no treatment on similar firms which have not innovated, $E\left(y^0_{l(t+n)} \mid S_{it} = 0\right)$.

To build an appropriate control group we apply a matching approach developed by Rosenbaum and Rubin (1983) and Heckman et al. (1997). The aim of matching techniques is to select from the sample of untreated firms a control group for which the distribution of observed characteristics in the pre-innovation period is as similar as possible to the distribution of treated firms (Becker and Ichino 2002). We estimate the probability of each of the innovating treatments at time t by a multinomial logit model. Following the previous literature, to estimate the probability of implementing an innovation treatment our explanatory variables are a set of firm characteristics for firm i at time *t-1*. The characteristics include the lagged values of the following variables: total employment and its squared value; average salary; TFP; capital intensity; cash-flow; and two variables measured at time t to capture a firm's affiliation to a French group or a foreign group. We also include industry (2-digit NACE rev.1 industries), years and regions dummies. In addition, because of the possible reverse causality between innovation and exporting, we also include firms' previous export intensity. In addition, by mitigating problems associated with reverse causality, this also enables us to avoid the potential impact of innovation on exports in the DiD estimation that may be driven by previous experience in international markets. This mean that our matching procedure is able to draw from the control group those firms with an export performance that is as similar as possible to that of the treated firms.[17]

Next we use the predicted probabilities (or propensity scores) from the multinomial logit estimations to match treated with control observations. We perform the matching within each 2-digit NACE sector and for each year in order to create more homogeneous control groups instead of matching across the entire sample of French manufacturing firms (Girma et al. 2004, De Loecker 2007 and Elliott et al. 2016). In this way, we take into account the large variance in the probability and the effect of starting an innovating activity on export performance across different manufacturing industries. This allows us to take into account also time-variant shocks which might have affected firms across different industries (Blundell and Dias 2009).

For our matching procedure we apply 1-to-1 nearest neighbor with caliper matching methods to match firms within the same industry and year and for which the distance between their propensity scores is the smallest possible within the specified caliper. We also impose a common support condition by dropping the treated firms whose propensity scores are higher than the maximum or lower than the minimum of those persistent non-innovators. The 1-to-1 nearest neighbor estimator associates the outcome y_{it} of treated firm i to a matched outcome. Tables A2, A3, A4 and A5 in

[17]All continuous variables in the multinomial logit model are expressed in natural logarithm except for the cash flow and export intensity variables. Table A1 presents the results of the multinomial logit used to estimate the propensity score. As expected, the majority of the variables have a positive and significant effect on the probability of undertaking one of the four treatments. TFP is generally insignificant. Average salary and cash flow despite being significant for the probability of the other three treatments, do not seem to be relevant for the introduction of process innovation. Previous export intensity and total employment have a positive and significant impact on the probability of undertaking any of the possible treatments, highlighting the importance of previous international experience and firm size as drivers of innovation. However, as indicated by Table A1, the effect of firm size is non-linear. Being a member of a French group also increases the probability of undertaking each of our four treatments.

the appendix present balancing tests of the quality of the matching procedure and of the comparability of the matched and control groups for each of our four treatments. We verify that the covariates used to estimate the probability of starting an innovative activity are not significantly different between the treated and the control group and we report the achieved percentage reduction in the standardised bias after the matching (Caliendo and Kopeinig 2008). The variance ratios between treated over non-treated indicate a good balance for most of the variables, with none of them being of particular concern for the quality of the matching.[18]

After matching we estimate a DiD regression. In this way we are able to estimate changes in the trade margins for exporting firms in the year they started innovating and the subsequent three years with respect to the pre-treatment level (t-1) and to compare it with the corresponding changes for exporting non-innovators. Due to a reduction in sample sizes as we move through time, we only consider the difference in exports for up to three years after the initial innovation.[19]

4 Results

We begin the results section of the paper with Table 2 that presents a series of summary statistics. We provide a summary for the differences between

[18]Different matching algorithms have been proposed. These mainly vary in terms of how the neighborhood of control individuals is built around the treated observations and provide different solutions to the trade-off between matching quality and variance (Caliendo and Kopeinig 2008). In robustness checks we perform nearest-neighbor with 5 matches and Kernel density matching (with a 0.03 bandwidth). The results are presented and discussed in the robustness checks section of the paper.

[19]Our sample of treated and control firms includes those firms that continue to export after treatment (10940 firms) and those firms that stopped exporting even after starting to engage in the innovation process (167 firms). In further analysis we estimate results including only continuous exporters the results of which are discussed in the robustness checks section of the paper.

our four alternative innovation treatment groups, measured for each firm at $t = 0$, for non-innovators and firms that switch to each of the four different treatments. The results show that firms who undertake both process and product innovation are larger, pay higher salaries and are the most productive. They also have the highest R&D and export intensities (3.98% and 31.13% respectively). Firms doing R&D only or product and process innovation only are relatively similar in terms of firm characteristics although process innovators tend to have higher values for the majority of variables. In terms of our export creation and destruction variables we find that for each group, in the year of treatment, new transactions are greater than terminated transactions. For new transactions specifically, we find that firms undertaking process innovation, whether alone or jointly with product innovation, have up to three times the value of new transactions. Subsequently, process innovators have higher net trade creation. This is despite process-innovator-only firms exporting on average to fewer countries and exporting fewer products.

[Table 2 about here]

Table 3 presents the results for total exports which captures changes to the intensive and extensive margins of trade. The results include the ATT effects for the four possible treatments in the year a firm started to innovate and for the following three years. The number of treated and untreated observations for each treatment and across sub-samples depends on the number of treated firms among the remaining cases, on the persistence of firms in our sample and the persistence of observations in the common support based on the matching technique used. The result is that the sample size decreases as t increases. Note that the reported coefficients are the difference in the differences, standard errors are reported in brackets below the ATT estimates.[20]

[Table 3 about here]

The results in Table 3 show that after starting to invest in R&D (top panel), although there is a marginally significant positive effect on exports in year t, total exports grow at a considerably higher rate in the following three years compared to similar firms that did not have any R&D expenditure. On average, compared to the control group, firms who invest in R&D have 31.8 percentage point (pp) higher growth rate of total exports after one year, 98.2 pp higher after two years and 109.8 pp higher after three years. A detailed look at the average treatment effects show that the difference between the two groups of firms is mainly driven by a negative growth rate of exports for the control group. More specifically, we find that for treated firms the growth rate of total exports is 12% after one year, 26% after 2 years, and 14.8% after 3 years. However the firms in the control group experience a negative growth in total exports of 19.4% after 1 year, 72% after 2 years, and 95% after 3 years.[21]

We find a similar effect on total exports for firms who have introduced product innovation but the effect is of a smaller magnitude in the first two years but of a similar magnitude in year 3 (29.1 pp, 67.5 pp and 107.6 pp respectively). Again these differences are driven by stable growth rates for treated firms (13.5%, 20.5%, and 30% in years 1, 2 and 3 respectively) and

[20] That is to say, the change in exports relative to the control group. For example, a negative coefficient on total exports could be the result of an increase in exports for the treated group that just happens to have grown more slowly that the exports of the control group. Likewise, a positive coefficient may mean that exports have fallen less quickly over that period relative to the control group.

[21] The full range of growth rates for the control and treated groups resulting from the matching procedure are not reported in the paper but are available from the authors upon request.

large negative growth rates for the control group (15.5%, 47%, and 77% in years 1, 2 and 3 respectively). For process innovators only, there is no significant uplift in exports until $t+2$ and $t+3$. In contrast, firms that undertake both product and process innovation at the same time experience an immediate impact that persists and increases for the next three years. In the first three treatments there is a lag of one year before total exports see a significant increase. Traditionally, it has been assumed this is due to the fact that it takes time for the results of an innovation to feed through into export markets (Isogawa et al. 2012). To understand whether it is the intensive or extensive margins of trade that are driving the change in total exports we now disentangle this effect in the different margins of exports.

Table 4 presents the results for the intensive and extensive margins. The intensive margin of trade is measured as the change in the value of exports for each country-pair transaction that existed at time $t-1$. The main finding is that the effect of innovation on total exports is mainly driven by the intensive margin. For all four treatments, the value of existing transactions increases for new innovators compared to the control group. The increase can be explained by better processes that reduce costs or product innovation that could, for example, increase the quality or tailor an existing product more closely to the tastes of the importer.

Turning to the extensive margins of exports we find a relatively limited impact of innovation on either the number of destinations or the total number of products exported. We observe a small difference in the number of countries two years after the initial innovation for all but only R&D investment. For product and process innovation alone, the growth rate is 11.8 pp and 16.6 pp higher respectively. This translates into a difference in the average number of destinations of around 2 to 3 countries.[22] In terms of the product extensive margin, we observe a limited difference between the number of products two years after the initial treatment for two of our treatments, however this difference drops out the following year. Our results support the findings of Bricongne et al. (2011) who show that export growth in France over this period was driven primarily by growth in the intensive margin.

[Table 4 about here]

The question then arises as to what explains this relative lack of significance on the extensive margins of trade. From previous theoretical predictions, we would expect innovations to positively affect the extensive margins, exporting new innovative products and opening new foreign markets. To answer this question we examine how innovation impacts net trade creation by looking at the value of new transactions and the value of terminated transactions in each year after the innovation takes place relative to the control group.[23] Table 5 presents these results. We first consider new transactions. Our results show a generally positive and significant impact of each of our treatments on the creation of new product-country transactions.

The finding of such a significant impact of innovation on new country-pair transactions begs the question why we do not see a difference in the

[22] The average number of destinations, at time $t-1$ is 23.5 for firms in the product innovation treatment group, 19.28 for firms in the process innovation treatment group, and 10.58 for firms in the control group. Firms in the product innovation treatment experience an 8.6% growth rate of the number of destinations while the matched controls experience a negative growth of 3%. For the process innovation treatment, the growth rate for the treated is 12.1% while the matched controls experience a decline in the number of destinations of 4.4%.

[23] The value of new and terminated transactions is zero by definition in year $t-1$. The analysis of new and terminated transactions is therefore in levels and not a DiD.

extensive margins of trade in Table 4 as each new transaction could potentially appear in at least one or both of the extensive margin categories (but not necessarily if, for example, it was an existing product exported to country 1 that was then exported to an existing destination country 2 that already imported product 2). The answer is found when we examine the terminated transaction results in Column (2). Compared to the matched controls, firms in all our treatment groups terminate a greater value of transactions and this result persists over the 3 years period after treatment.

These results translate into an initial net trade creation (Column 3) that is slower for treated firms compared to the controls. However, the slower pace of net trade is not statistically significant. Two years after treatment, in $t+2$ and $t+3$ we observe a greater trade creation, relative to the control group, for all four treatments. The results are consistent with the previous predictions about firms starting new trade relationships with smaller volumes and increasing them over time as the new relationships gain traction (Albornoz et al. 2012).

Similarly, if a new product is particularly disruptive it can lead to initially large declines in exports to existing customers. Our findings also explain why there is no significant increase in total exports in the year of the innovation for product and process innovation alone (in Table 3). The increase in the intensive margin that we see in Table 4 is offset by the termination of a larger number of existing transactions.

Our results suggest that the lack of evidence of a significant impact on the extensive margin of trade is not a result of inactivity on behalf of new innovators, but has more to do with the high churn rate of both products and destinations, as firms terminate some product-country transactions and start other new ones which has the effect of broadly cancelling each other out at least in the first two year following the innovation activity.[24]

[Table 5 about here]

To illustrate how each of the different margins fit together, Figure 1 presents the results for R&D expenditure (the first treatment) and shows how the treated group diverge from the control group over time relative to *t-1*.

[Figure 1 about here]

Figure 1 shows that for firms undertaking R&D investment the positive and significant coefficient for the intensive margin is driven by exports falling less slowly that for those firms that do not innovate. For the extensive margin, firms that innovate are able to maintain or slightly increase the number of countries and products while non-innovators see a fall in both extensive margins. Looking at new and terminated transactions provides further explanations. In both cases new and terminated transactions for innovators are greater than for non-innovators but the gap begins to widen for new transactions over time. This is reflected in the figure for net trade which shows how overall the net trade for innovators remains relatively flat while non-innovators see terminated transactions exceeding the new ones in the following years with a negative net impact on total exports. These striking results suggest that firms need to innovate in order to maintain their current position in the competitive global market, otherwise firms

[24] Recall that the new and terminated transactions are in levels and that net trade creation is the log of the differences between new and terminated transactions hence the coefficients between Table 3 and 4 cannot be directly compared to those of Table 5.

might expect to see a drop in their exports without recourse to some element of product development or innovation activity as a consequence of the tougher foreign competition from developed and developing countries. To summarise, innovation helps French exporters in maintaining their comparative advantage vis-a-vis foreign competitors by continuously replacing obsolete products with new innovative ones and by accessing new foreign markets with tailored-made goods.[25]

5 Robustness checks

As previously discussed in the methodological section, we perform a series of robustness checks in order to verify the validity of our findings. In particular, we replicate our results from Table 3 applying a Kernel matching algorithm with a bandwidth of 0.03 (in unreported results we also applied a kernel matching algorithm with a bandwidth of 0.01) and nearest-neighbor matching with 5 matches. The results in Columns (1) and (2) of Table 6 show that the different matching procedures are broadly consistent in terms of significance and magnitude of the coefficients. Equivalent results for Tables 4 and 5 are available upon request but show no qualitative or quantitative differences.

[Table 6 about here]

Our next robustness check is to re-estimate our results using a sample of firms that continuously export between $t-1$ and $t+3$ (Column 3 of Table 6). The results are very similar in terms of significance and magnitudes.

[25] A similar story is told for the other three treatments but the figures are not presented for reasons of space.

Finally, we have tested the goodness of the PSM-DiD methodology by re-estimating the ATTs on the basis of placebo treatments. More specifically, we drew from the sample of non-treated a random sample of firms for each of our four treatments (we have selected a proportion of firms in each treatment sample that reflects the distribution of treated in our data) and compared their export performance to matched controls firms (Elliott et al. 2016). We have simulated this process 500 times for each of the ATTs. Out of the 112 ATTs we estimate, only 2 of the effects that we observe (the impact of product and process innovation on the Intensive Margin in time $t + 2$ and the impact of investing in R&D on Total Exports in t+2) appears to be significant when we apply a placebo treatment, validating our main results and the efficiency of the PSM-DiD methodology in identifying the genuine causal effect of innovation on the different margins of trade.

6 Conclusions

In this paper we exploit four unique datasets to investigate the impact of the innovating activities of French firms on their trade margins for the period 1999-2007. Our main contribution is to decompose the effect of innovation into the extensive and intensive margins of trade and then disaggregate further to examine the role of innovation in creating new transactions and terminating others. Our empirical approach allows us to explain the absence of a strong effect of innovation on the extensive margins of exports. For the first time, we establish at the firm level the impact of innovation activities on exporters' performance and how this consists on the one hand in an enriched product range and the opening of new export markets, and on the other hand in an increase in the value of exports of existing products to current customers. We assess the effect of different forms of innovation on export performance, by simultaneously taking into account both innovation input and output measures and the simultaneous introduction of both product and process innovations.

Our results show a positive and significant effect of R&D expenditure on total exports that is robust and consistent across different estimations. In terms of dynamics, we find that firms implementing both product and process innovations at the same time see an immediate uplift in exports relative to the control group, with a growth rate of exports 19.9 pp higher in year t increasing to a differential of 74.3 pp after three years. Two years after the initial innovation all of our treatments show a significantly higher rate of growth in total exports with a differential that ranges between 49.7 pp for process innovation only to 98.2 pp for R&D expenditure.

The existence of a lagged effect of innovation on exports has previously been assumed to be a result of the time that it takes for a new innovation to be commercially exploited and exported to new markets. What we show in this paper is that total exports are driven primarily by differences in the intensive margin with only a small difference in the number of countries served. The explanation is that while firms tend to maintain and deepen their most important trading relationships, innovation also results in considerable churn in country-pair transactions. This is consistent with the idea of new innovations cannibalising existing exports as firms transition from older to newer products.

The differences between our treated and control groups for the intensive margin is also consistent with innovation resulting in higher quality varieties or process innovation leading to lower costs of production. Perhaps the most important finding is that during this period, French firms that innovated were able to maintain the value of their exports while non-innovators experienced declining exports. In this sense, it can be said that firms need to innovate in order to survive and that a failure to do so can lead to fairly dramatic falls in the value of exports.

Our results imply that innovation is more important than ever if developed and mature economies such as France are to be as prepared as possible to face ever increasing international competition from China and other rapidly industrializing countries. Upgrading knowledge of foreign markets and introducing tailor-made goods designed to penetrate distant and difficult countries should be considered an important part of any industrial strategy. However, innovation is a dynamic, time-consuming and resources-intensive process, that also has the ability to reduce the number of products and countries that a firm may export to through a "creative destruction" effect. Such a result is most likely due to the costs of adaptation, production changes and the time needed in order to commercially exploit new technologies, brands or products especially in foreign markets.

Tables and Figures

Table 1: Firm performance by exporting and innovating status over the period 1999-2007.

ALL FIRMS	Exporters	Non-Exporters	All Firms
Nb. of Firms	16,790	13,021	27,791
Employment	178	54	138
Av. Salary (EUR)	26,291	22,706	25,127
Tot. Sales (EUR th.)	47,290	7,820	34,469
Tot. Investment (EUR th.)	1,548	243	1,124
TFP	4.598	4.25	4.485
Cash Flow	0.046	0.03	0.041
R&D Intensity	0.69%	0.17%	0.52%
Export Intensity	21.02%	0.00%	14.19%
INNOVATORS	Exporter	Non-Exporter	All Firms
Nb. of Firms	3,660	229	3,854
Employment	572	172	561
Av. Salary (EUR)	30,443	26,215	30,332
Tot. Sales (EUR th.)	163,966	33,571	160,538
Tot. Investment (EUR th.)	5,411	1,329	5,304
TFP	4.92	4.61	4.914
Cash Flow	0.056	0.052	0.056
R&D Intensity	4.64%	20.9%	5.07%
Export Intensity	33.84%	0.00%	32.95%

Note: Employment calculated as average number of full-time employees. Average salary represents average annual salary of full-time employees in Euro. Total sales calculated as average total sales (domestic + foreign) in thousands of Euro. Total investment calculated as average of firm total investment in fixed tangible assets in thousands of Euros. Productivity is calculated as log of total factor productivity following the De Loecker (2007) approach. Cash-flow calculated as the ratio between firm net income and total sales. R&D and export intensities calculated as the ratio of firm total expenditure in R&D or total exports over total sales. All monetary values deflated using OECD production price indexes at the industry-level for France in 2000 as a baseline. Firms can be included as a non-exporter and as an exporter if they change status within our time period. The means are calculated for each year that are classified as an exporter or non-exporter.

Table 2: Summary statistics for firms in different treatment groups at time t=0.

	Only R&D Investment (No. Firms: 388)		**Product Innovation** (No. Firms: 593)		**Process Innovation** (No. Firms: 259)		**Prod. and Proc. Inn.** (No. Firms: 1,304)		**Non-Innovators** (No. Firms: 8,563)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Tot. Employment	187.36	301.16	238.14	356.4	249.3	398.65	409.25	1,019	96.5	307.78
Av. Salary	26,432	8,301	27,810	7,776	26,764	7,532	29,147	16,095	25,315	8,127
TFP	4.71	0.604	4.83	0.649	4.72	0.65	4.862	0.688	4.51	0.581
Tot. Sales (EUR th.)	49,471	153,302	60,450	123,379	67,635	173,115	126,499	897,514	26,046	286,052
Cash Flow	0.055	0.079	0.051	0.082	0.049	0.116	0.055	0.093	0.04	0.082
Tot. Investment (EUR th.)	1,598	5,412	1,942	7,841	2,328	5,477	4,271	30,100	901.32	20,405
R&D Intensity	2.67%	3.78%	3.12%	5.08%	2.81%	5.17%	3.98%	6.17%	0.00%	0.00%
Export Intensity	27.96%	24.5%	28.21%	25.44%	28.6%	25.5%	31.13%	25.00%	17.4%	21.5%
Tot. Exports (EUR th.)	14,320	43,190	17,736	59,995	23,311	91,994	46,814	388,253	6,151	81,634
Intensive Margin (EUR th.)	12,793	42,096	15,991	57,791	17,695	60,853	41,743	383,007	5,358	70,914
New Transactions (EUR th.)	1,285	3,911	1,499	4,296	4,351	24,792	4,651	25,624	601	11,399
Terminated Transactions (EUR th.)	976	2,853	1,268	4,001	2,997	17,512	3,104	25,036	410	8,077
Net Trade Creation (EUR th.)	306	3,022	231	2,261	1,354	10,895	1,547	18,198	190	5,526
Country Ext. Margin	20.51	18.03	24.14	19.75	19.99	18.25	28.34	23.68	10.73	12.82
Product Ext. Margin	20.91	26.39	22.87	28.28	20.57	38.04	30.3	43,02	12.05	21.3

Notes: Mean and standard deviation reported for each variable. The different categories denote firms that invested in R&D for the first time, successfully introduced product innovation or process innovation, introduced a product and a process innovation jointly in a given year or have never performed any R&D activity. Employment is the average number of full-time employees. Average annual salary of full-time employees in Euros. Total sales calculated as average total sales (domestic+foreign) in thousand of Euro. Total investment calculated as average of firm total investment in fixed tangible assets in thousands of Euros. Productivity calculated as log of total factor productivity following the De Loecker (2007) approach. Cash-flow calculated as the ratio between firm net income and total sales. Export intensity calculated as the ratio of firm total exports over total sales. Foreign and French group are dummy variables equal to 1 if the firm is part of a foreign or French business group and 0 otherwise. R&D intensity calculated as average ratio of firms total expenditure on R&D over total sales (R&D Inquiry data). Total exports includes data on all intra-EU shipments over €100,000 and extra-EU over €1,000 collected by the French Custom Agency in thousands of Euros. The intensive margin is calculated as the value of the set of product-country transactions that the firm exported at time $t-1$. New transactions are measured as the value, in thousands of Euros of all new product-country transactions that the were not observed at time $t-1$. Terminated transactions are measured as the value, in thousands of Euros, of product-country transactions that the firm exported in $t-1$ but no longer exports. Net trade creation is the difference between new and terminated transactions. Product extensive margin calculated as average number of products exported by French firms. Country extensive margin calculated as average number of foreign markets served by French firms. All monetary values deflated using OECD production price indexes at the industry-level for France in 2000 as a baseline.

Table 3: Impact of innovation on firm's total exports - ATT effects estimated with 1-to-1 nearest-neighbour matching.

	Total Exports			
	t	t+1	t+2	t+3
	Only R&D Investment			
ATT	0.177	0.318*	0.982***	1.098***
s.e.	(0.105)	(0.13)	(0.22)	(0.32)
Treated	310	301	229	148
Controls	8,448	7,961	7,584	6,180
	Product Innovation			
ATT	-0.007	0.291**	0.675***	1.076***
s.e.	(0.056)	(0.106)	(0.155)	(0.255)
Treated	470	433	388	259
Controls	8,448	7,961	7,584	6,180
	Process Innovation			
ATT	-0.044	0.072	0.497*	0.786*
s.e.	(0.097)	(0.136)	(0.251)	(0.350)
Treated	201	185	152	117
Controls	8,448	7,961	7,584	6,180
	Product & Process Innovation			
ATT	0.199**	0.265**	0.704***	0.743***
s.e.	(0.074)	(0.087)	(0.141)	(0.197)
Treated	858	813	664	452
Controls	8,448	7,961	7,584	6,180

Note: ATT effect estimated using a difference-in-differences technique with propensity score 1-to-1 nearest-neighbor with caliper (0.05) matching procedure. Standard errors (s.e.) reported in parentheses. *** $p<0.001$, ** $p<0.01$, * $p<0.05$. The number of firms included in the treated and control groups is reported. The outcome variable: total exports has been built as previously described using the Custom Agency data. We report the ATT effects of the four possible treatments of investing in R&D ($R\&D$), introducing a product innovation (Pd), a process innovation (Pc) or to jointly introduce a product and a process innovation ($PdPc$) against not having innovated at all for the following three years after the treatment. Controls refers to the number of firms in the pool from which 1-1 matching then takes place.

Table 4: Impact of innovation on firm's intensive and extensive margins - ATT effects estimated with 1-to-1 nearest-neighbor matching.

	Intensive Margins				**Country Ext. Margin**				**Product Ext. Margin**			
	t	t+1	t+2	t+3	t	t+1	t+2	t+3	t	t+1	t+2	t+3
	Only R&D Investment											
ATT	0.431	0.862**	2.059***	1.859***	-0.008	0.005	0.111	0.14	-0.03	0.02	0.19**	0.068
s.e	(0.238)	(0.295)	(0.401)	(0.544)	(0.032)	(0.04)	(0.057)	(0.072)	(0.046)	(0.05)	(0.071)	(0.088)
Treated	310	301	229	148	310	301	229	148	310	301	229	148
Controls	8,448	7,961	7,584	6,180	8,448	7,961	7,584	6,180	8,448	7,961	7,584	6,180
	Product Innovation											
ATT	0.266	0.554*	1.012**	2.487***	-0.004	0.018	0.118**	0.11	-0.039	-0.003	0.043	0.08
s.e	(0.169)	(0.250)	(0.312)	(0.468)	(0.025)	(0.031)	(0.04)	(0.064)	(0.034)	(0.041)	(0.055)	(0.075)
Treated	470	433	388	259	470	433	388	259	470	433	388	259
Controls	8,448	7,961	7,584	6,180	8,448	7,961	7,584	6,180	8,448	7,961	7,584	6,180
	Process Innovation											
ATT	0.220	0.678	1.945***	2.284**	0.004	0.04	0.166*	0.102	-0.024	-0.055	0.160	0.156
s.e	(0.269)	(0.383)	(0.535)	(0.716)	(0.038)	(0.044)	(0.07)	(0.083)	(0.052)	(0.065)	(0.092)	(0.092)
Treated	201	185	152	117	201	185	152	117	201	185	152	117
Controls	8,448	7,961	7,584	6,180	8,448	7,961	7,584	6,180	8,448	7,961	7,584	6,180
	Product & Process Innovation											
ATT	0.732***	0.776***	1.405***	1.507***	0.007	0.021	0.127***	0.0852	0.015	0.035	0.190***	0.041
s.e	(0.167)	(0.201)	(0.264)	(0.368)	(0.024)	(0.027)	(0.037)	(0.049)	(0.031)	(0.035)	(0.045)	(0.056)
Treated	858	813	664	452	858	813	664	452	858	813	664	452
Controls	8,448	7,961	7,584	6,180	8,448	7,961	7,584	6,180	8,448	7,961	7,584	6,180

Note: ATT effect estimated using a difference-in-differences technique with propensity score 1-to-1 nearest-neighbor with caliper (0.05 matching procedure). Standard errors (s.e.) reported in parentheses. *** $p<0.001$, ** $p<0.01$, * $p<0.05$. The number of firms included in the treated and control groups is reported. The outcome variables; intensive margins, country and product extensive margins have been built as previously described using the Custom Agency data. We report the ATT effects of the four possible treatments of investing in R&D ($R\&D$), introducing a product innovation (Pd), a process innovation (Pc) or to jointly introduce a product and a process innovation ($PdPc$) against not having innovated at all for the following three years after the treatment. Controls refers to the number of firms in the pool from which 1-1 matching then takes place

Table 5: Impact of innovation on firm's Trade Creation - ATT effects estimated with 1-to-1 nearest-neighbor matching.

	New Transactions				**Terminated Transactions**				**Net Trade Creation**			
	t	t+1	t+2	t+3	t	t+1	t+2	t+3	t	t+1	t+2	t+3
	Only R&D Investment											
ATT	1.074***	1.146***	1.746***	2.383***	1.325***	0.988***	0.784**	1.057***	-0.251	0.158	0.961**	1.326**
s.e	(0.297)	(0.278)	(0.337)	(0.482)	(0.298)	(0.265)	(0.286)	(0.318)	(0.290)	(0.275)	(0.321)	(0.407)
Treated	310	301	229	148	310	301	229	148	310	301	229	148
Controls	8,448	7,961	7,584	6,180	8,448	7,961	7,584	6,180	8,448	7,961	7,584	6,180
	Product Innovation											
ATT	0.414	0.526*	1.204***	1.697***	0.871**	0.939***	0.528*	0.683*	-0.456	-0.413	0.676**	1.014**
s.e	(0.247)	(0.240)	(0.299)	(0.406)	(0.278)	(0.268)	(0.264)	(0.335)	(0.239)	(0.252)	(0.258)	(0.382)
Treated	470	433	388	259	470	433	388	259	470	433	388	259
Controls	8,448	7,961	7,584	6,180	8,448	7,961	7,584	6,180	8,448	7,961	7,584	6,180
	Process Innovation											
ATT	1.482***	1.110**	1.734***	1.933***	1.504***	1.090**	0.920*	1.224**	-0.021	-0.02	0.813	0.709
s.e	(0.408)	(0.415)	(0.464)	(0.497)	(0.375)	(0.351)	(0.363)	(0.460)	(0.362)	(0.355)	(0.430)	(0.493)
Treated	201	185	152	117	201	185	152	117	201	185	152	117
Controls	8,448	7,961	7,584	6,180	8,448	7,961	7,584	6,180	8,448	7,961	7,584	6,180
	Product & Process Innovation											
ATT	0.803***	0.785***	1.196***	1.354***	0.585**	0.584**	0.309	0.728**	0.219	0.202	0.886***	0.626*
s.e	(0.201)	(0.197)	(0.233)	(0.294)	(0.201)	(0.195)	(0.196)	(0.242)	(0.196)	(0.190)	(0.212)	(0.282)
Treated	858	813	664	452	858	813	664	452	858	813	664	452
Controls	8,448	7,961	7,584	6,180	8,448	7,961	7,584	6,180	8,448	7,961	7,584	6,180

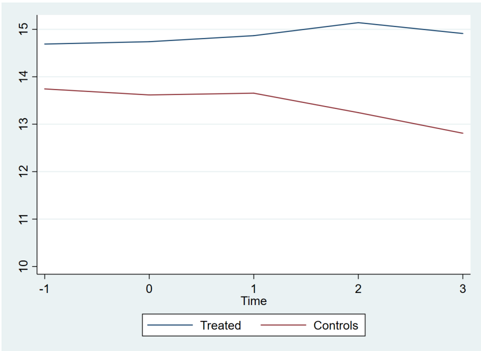
Note: ATT effect estimated using a difference-in-differences technique with propensity score 1-to-1 nearest-neighbor with caliper (0.05) matching procedure. Standard errors (s.e.) reported in parentheses. *** $p<0.001$, ** $p<0.01$, * $p<0.05$. The number of firms included in the treated and control groups is reported. The outcome variables; New transaction and terminated transactions have been built as previously described using the Custom Agency data. The Variable Net Trade Creation is the log difference between new and terminated transactions. We report the ATT effects of the four possible treatments of investing in R&D ($R\&D$), introducing a product innovation (Pd), a process innovation (Pc) or to jointly introduce a product and a process innovation ($PdPc$) against not having innovated at all for the following three years after the treatment. Controls refers to the number of firms in the pool from which 1-1 matching then takes place.

Table 6: Impact of innovation on firm's Total Exports - Robustness Checks.

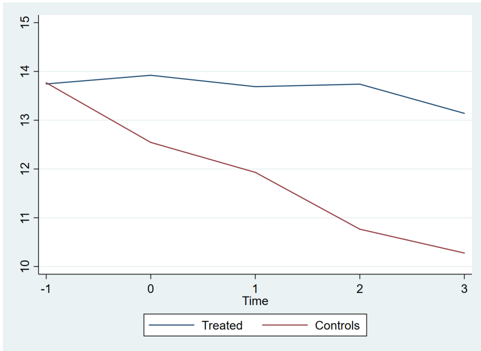
	Nearest Neighbor Matching				**Kernel Matching**				**Continuous Exporters**			
	t	t+1	t+2	t+3	t	t+1	t+2	t+3	t	t+1	t+2	t+3
	Only R&D Investment											
ATT	0.188**	0.356***	0.865***	1.382***	0.08	0.237***	0.947***	0.997***	0.086	0.312**	1.128***	0.948***
s.e	(0.067)	(0.087)	(0.127)	(0.205)	(0.064)	(0.071)	(0.111)	(0.236)	(0.07)	(0.118)	(0.232)	(0.323)
Treated	383	315	238	197	323	314	238	179	310	301	229	148
Controls	8,448	7,961	7,584	6,180	8,448	7,961	7,584	6,180	8,303	7,842	7,461	6,108
	Product Innovation											
ATT	0.113*	0.224**	0.746***	1.103***	0.056	0.292***	0.754***	1.035***	-0.015	0.302*	0.638***	1.059***
s.e	(0.056)	(0.08)	(0.114)	(0.184)	(0.061)	(0.08)	(0.104)	(0.162)	(0.053)	(0.118)	(0.161)	(0.253)
Treated	589	449	403	328	486	447	402	300	470	433	388	259
Controls	8,448	7,961	7,584	6,180	8,448	7,961	7,584	6,180	8,303	7,842	7,461	6,108
	Process Innovation											
ATT	0.129	0.131	0.68***	0.961***	0.136	0.078	0.625***	0.835***	-0.08	0.07	0.538*	0.591*
s.e	(0.075)	(0.114)	(0.160)	(0.206)	(0.071)	(0.101)	(0.127)	(0.187)	(0.089)	(0.136)	(0.237)	(0.273)
Treated	258	195	156	134	211	195	156	124	201	185	152	117
Controls	8,448	7,961	7,584	6,180	8,448	7,961	7,584	6,180	8,303	7,842	7,461	6,108
	Product & Process Innovation											
ATT	0.204***	0.257***	0.649***	0.970***	0.130	0.315***	0.605***	0.744***	0.089	0.245**	0.669***	0.697***
s.e	(0.053)	(0.06)	(0.102)	(0.150)	(0.072)	(0.085)	(0.135)	(0.209)	(0.051)	(0.078)	(0.134)	(0.195)
Treated	1,293	1,061	912	771	1,108	1,059	910	715	863	818	665	454
Controls	8,448	7,961	7,584	6,180	8,448	7,961	7,584	6,180	8,303	7,842	7,461	6,108

Note: ATT effect estimated using a difference-in-differences technique with propensity score nearest-neighbour, with 5 matches, matching procedure in column (1), kernel matching with a bandwidth of 0.03 matching procedure in column (2) and 1-to-1 nearest-neighbor with caliper (0.05) matching procedure on the sample of continuous exporters in column (3). Standard errors (s.e.) reported in parentheses. *** $p<0.001$, ** $p<0.01$, * $p<0.05$. The number of firms included in the treated and control groups is reported. The outcome variable: total exports has been built as previously described using the Custom Agency data. We report the ATT effects of the four possible treatments of investing in R&D ($R\&D$), introducing a product innovation (Pd), a process innovation (Pc) or to jointly introduce a product and a process innovation ($PdPc$) against not having innovated at all for the following three years after the treatment. Controls refers to the number of firms in the pool from which 1-1 matching then takes place for the 1-1 matching with caliper and the full set of controls for the Kernel matching.

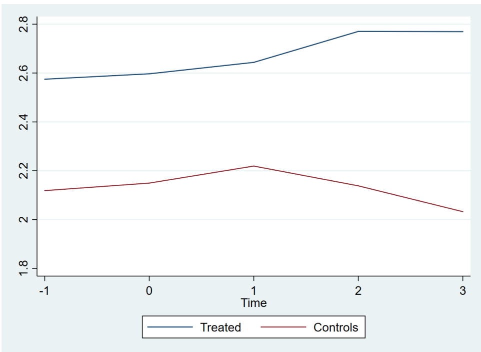
Figure 1: Trajectories of Trade Margins: Treated vs. Controls (R&D Investment Treatment)



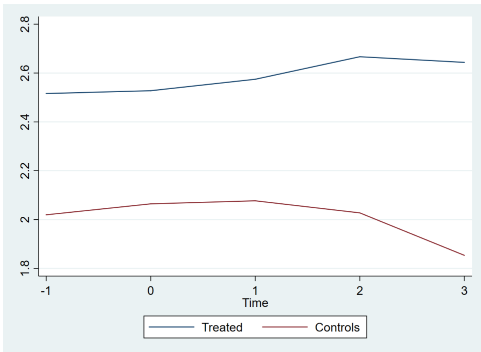
(a) Total Exports



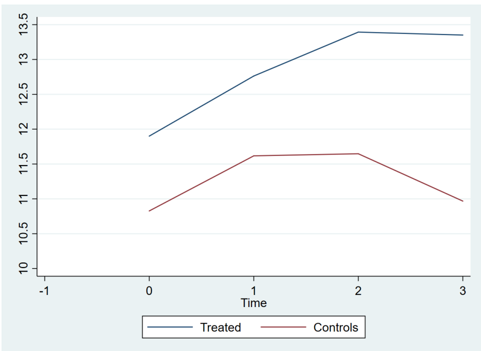
(b) Intensive Margin



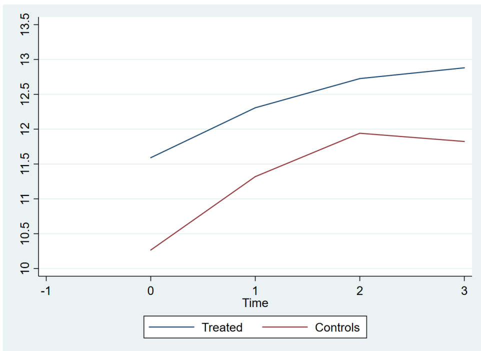
(c) Country Extensive Margin



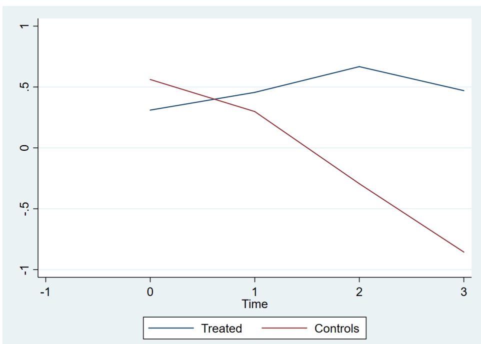
(d) Product Extensive Margin



(e) New Transactions



(f) Terminated Transactions



(g) Net Trade

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A Appendix

Table A1: Multinomial logit estimation to estimate the propensity score 1999-2007

Treatment	(1) R&D	(2) Pd	(3) Pc	(4) PdPc
$Employment_{t-1}$	2.4740***	2.9237***	2.4138***	2.1395***
	(0.4193)	(0.3472)	(0.4697)	(0.2470)
$Employment^2_{t-1}$	-0.184***	-0.211***	-0.166***	-0.115***
	(0.0421)	(0.0341)	(0.0454)	(0.0239)
$Av.\ Salary_{t-1}$	1.0104***	0.9997***	-0.247	1.3040***
	(0.3164)	(0.2746)	(0.3988)	(0.2118)
TFP_{t-1}	-0.240	0.0417	0.2372	-0.188
	(0.1755)	(0.1525)	(0.2174)	(0.1187)
$Export\ Intensity_{t-1}$	1.6452***	1.4878***	1.3468***	1.7298***
	(0.2387)	(0.2060)	(0.2880)	(0.1601)
$Capital\ Intensity_{t-1}$	0.0958	0.1592**	0.2969***	0.1547***
	(0.0632)	(0.0538)	(0.0819)	(0.0424)
$Cash\ Flow_{t-1}$ t-1	2.3329**	1.8380*	-0.686	1.9368***
	(0.8360)	(0.7393)	(0.8440)	(0.5653)
$Foreign\ Group_t$	0.2839	0.1045	0.2287	0.3019*
	(0.2032)	(0.1678)	(0.2428)	(0.1313)
$French\ Group_t$	0.7612***	0.4921***	0.6119**	0.6913***
	(0.1629)	(0.1391)	(0.2034)	(0.1096)
Observations	11,091	11,091	11,091	11,091

Note: The estimator used is a multinomial logit. Unreported year, region and industry (NACE rev.1, 2-digit) dummies are included. Robust standard errors reported in parentheses. *** $p<0.001$, ** $p<0.01$, * $p<0.05$. The dependent variables *R&D*, *Pd*, *Pc* and *PdPc* denotes the possible innovating treatments of investing in R&D, introducing a product innovation, a process innovation or to jointly introduce a product and a process innovation respectively and are equal to 1 if firms have been treated for the first time and 0 otherwise. As regressors, empl is the log of the numbers of employees, salary is the log of wage per employee calculated as the ratio of total labor cost over total number of employees, TFP is the log of the total factor productivity calculated following the De Loecker (2007) approach. Export intensity is the ratio of a firm total exports over total sales, capital intensity is the log value of total investment in fixed tangible assets over total employment, cash-flow is calculated as the ratio between firm net income and total sales, while foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise.

Table A2: Matching propensity average balancing test for the *R&D Investment* propensity score

	Mean		Bias		Equality of Means	
Variable	Treated	Control	Std. Bias	Reduct Bias	t	p>|t|
$Employment_{t-1}$	4.6541	4.439	22.5	63.8	2.68	0.008
$Employment^2_{t-1}$	22.769	20.594	23.9	59.9	2.8	0.005
$AV.\ Salary_{t-1}$	3.2788	3.2373	15.6	31.6	1.89	0.06
TFP_{t-1}	4.6842	4.5975	14.6	59.4	1.69	0.091
$Export\ Intensity_{t-1}$	0.26306	0.24482	8.1	82.1	0.9	0.368
$Capital\ Intensity_{t-1}$	3.8069	3.6783	12.7	14.9	1.52	0.129
$Cash\ Flow_{t-1}$	0.04153	0.03124	13.9	17.5	1.48	0.14
$Foreign\ Group_t$	0.26452	0.24194	5.6	75.1	0.65	0.519
$French\ Group_t$	0.59032	0.6	-2	93.8	-0.25	0.806
Sample Stat.	R_2	$LRchi_2$	$p > chi_2$	Mean Bias	Med.Bias	
	0.023	19.47	0.035	12.5	13.3	

Note: Columns (2) and (3) present the mean value of each control variable for firms in the treated and control groups. In columns (4) and (5) we display the median standard bias across all the covariates included in the multinomial logit estimation and the percentage reduction in the bias after the application of the matching procedure. Columns 6 and 7 report the t-tests for the equality of the mean values of firms in the matched sample compared to those in unmatched sample. Finally, in the bottom row we present a summary of statistics regarding the whole sample. First, we include the pseudo R^2 from the probit estimation of the treatment on covariates and the corresponding χ^2 statistic and p-value of likelihood-ratio test of joint significance of covariates. In addition, we present the mean and median bias as summary indicators of the distribution of bias across the samples.

Table A3: Matching propensity average balancing test for the *Product Innovation* propensity score

	Mean		Bias		Equality of Means	
Variable	Treated	Control	Std. Bias	Reduct Bias	t	p>|t|
$Employment_{t-1}$	4.8715	4.6875	18.8	77.9	2.79	0.005
$Employment^2_{t-1}$	24.898	22.855	21.3	73.7	3.08	0.002
$Av.\ Salary_{t-1}$	3.3212	3.3125	3.4	91.2	0.51	0.612
TFP_{t-1}	4.8036	4.7629	6.6	87.8	0.93	0.352
$Export\ Intensity_{t-1}$	0.26707	0.25563	4.9	88.9	0.69	0.489
$Capital\ Intensity_{t-1}$	3.9259	3.7482	18	30.8	2.7	0.007
$Cash\ Flow_{t-1}$	0.03549	0.03444	1.4	90.1	0.23	0.817
$Foreign\ Group_t$	0.30426	0.27234	7.7	78.7	1.08	0.281
$French\ Group_t$	0.5383	0.5766	-7.7	63.6	-1.18	0.238
Sample Stat.	R_2	$LRchi_2$	$p > chi_2$	Mean Bias	Med.Bias	
	0.029	38.08	0	10.2	7.7	

Note: Columns (2) and (3) present the mean value of each control variable for firms in the treated and control groups. In columns (4) and (5) we display the median standard bias across all the covariates included in the multinomial logit estimation and the percentage reduction in the bias after the application of the matching procedure. Columns (6) and (7) report the t-tests for the equality of the mean values of firms in the matched sample compared to those in unmatched sample. Finally, in the bottom row we present a summary of statistics regarding the whole sample. First, we include the pseudo R^2 from the probit estimation of the treatment on covariates and the corresponding χ^2 statistic and p-value of likelihood-ratio test of joint significance of covariates. In addition, we present the mean and median bias as summary indicators of the distribution of bias across the samples.

Table A4: Matching propensity average balancing test for the *Process Innovation* propensity score

Variable	Mean		Bias		Equality of Means	
	Treated	Control	Std. Bias	Reduct Bias	t	p>|t|
$Employment_{t-1}$	4.874	4.5857	29	65.6	2.89	0.004
$Employment^2_{t-1}$	24.991	21.783	32.8	59.2	3.21	0.001
$Av.\ Salary_{t-1}$	3.2898	3.2452	16.6	20.5	1.68	0.093
TFP_{t-1}	4.6827	4.5887	14.9	55.4	1.37	0.17
$Export\ Intensity_{t-1}$	0.26734	0.23452	14.2	67.6	1.33	0.183
$Capital\ Intensity_{t-1}$	3.9453	3.7572	19.2	37.6	1.75	0.08
$Cash\ Flow_{t-1}$	0.03814	0.03703	1	64.5	0.13	0.897
$Foreign\ Group_t$	0.33831	0.29851	9.5	73.8	0.86	0.393
$French\ Group_t$	0.52239	0.49254	6	72.1	0.6	0.551
Sample Stat.	R_2	$LRchi_2$	$p > chi_2$	Mean Bias	Med.Bias	
	0.041	22.94	0.011	15.4	14.5	

Note: Columns (2) and (3) present the mean value of each control variable for firms in the treated and control groups. In columns (4) and (5) we display the median standard bias across all the covariates included in the multinomial logit estimation and the percentage reduction in the bias after the application of the matching procedure. Columns (6) and (7) report the t-tests for the equality of the mean values of firms in the matched sample compared to those in unmatched sample. Finally, in the bottom row we present a summary of statistics regarding the whole sample. First, we include the pseudo R^2 from the probit estimation of the treatment on covariates and the corresponding χ^2 statistic and p-value of likelihood-ratio test of joint significance of covariates. In addition, we present the mean and median bias as summary indicators of the distribution of bias across the samples.

Table A5: Matching propensity average balancing test for the *Product & Process Innovation* propensity score

Variable	Mean		Bias		Equality of Means	
	Treated	Control	Std. Bias	Reduct Bias	t	p>|t|
$Employment_{t-1}$	4.8032	4.8154	-1.1	98.9	-0.23	0.816
$Employment^2_{t-1}$	24.275	24.346	-0.6	99.3	-0.13	0.896
$Av.\ Salary_{t-1}$	3.326	3.3292	-1.2	97.4	-0.24	0.808
TFP_{t-1}	4.7374	4.7259	1.8	96.4	0.35	0.728
$Export\ Intensity_{t-1}$	0.2752	0.25346	9.5	83.3	1.83	0.068
$Capital\ Intensity_{t-1}$	3.8983	3.81	8.9	70.1	1.75	0.08
$Cash\ Flow_{t-1}$	0.03676	0.03736	-0.7	94.4	-0.14	0.886
$Foreign\ Group_t$	0.32867	0.34615	-4.1	91	-0.77	0.444
$French\ Group_t$	0.52797	0.52331	0.9	95.1	0.19	0.847
Sample Stat.	R_2	$LRchi_2$	$p > chi_2$	Mean Bias	Med.Bias	
	0.004	9.99	0.441	3.1	1.5	

Note: Columns (2) and (3) present the mean value of each control variable for firms in the treated and control groups. In columns (4) and (5) we display the median standard bias across all the covariates included in the multinomial logit estimation and the percentage reduction in the bias after the application of the matching procedure. Columns (6) and (7) report the t-tests for the equality of the mean values of firms in the matched sample compared to those in unmatched sample. Finally, in the bottom row we present a summary of statistics regarding the whole sample. First, we include the pseudo R^2 from the probit estimation of the treatment on covariates and the corresponding χ^2 statistic and p-value of likelihood-ratio test of joint significance of covariates. In addition, we present the mean and median bias as summary indicators of the distribution of bias across the samples.

Table A6: Definition of Variables

Variable	Definition
Tot. Exports	Firm i exports for intra-EU shipments over € 100,000 and extra-EU over € 1,000 (Customs Data).
Export Intensity	Ratio of firm i total exports over total sales at time t (Customs and FBS Data).
Intensive Margin	total value, in each year, of the set of product-country transactions exported by firm i in year $t-1$ (Customs Data).
Product Extensive Margin	Count variable for the number of products exported by each firm (Customs Data).
Country Extensive Margin	Count variable for the number of foreign markets served by each firm (Custom Data).
New Transactions	total value of the set of product-country transactions that were not exported by firm i in year $t-1$ (Customs Data).
Terminated Transactions	Cumulative value of the set of product-country transactions that were exported by firm i in year $t-1$ but are no longer exported (Customs Data).
Net Trade Creation	The difference between the log value of New Transactions and log value of terminated transactions (Customs Data).
Employment	Size of firm i measured as the log of total employees (FBS Data).
Av. Salary	The wage per employee calculated as the ratio of total labor payments over total employment (FBS Data).
Total Sales	Firm i total sales (domestic+foreign) (FBS data).
Total Investment	Firm i total investment in fixed tangible assets (FBS data).
Cash flow	The ratio between firm i net income and total sales (FBS Data).
TFP	The log of total factor productivity calculated following the De Loecker (2007) approach. We use value added as a proxy for output, including in the estimation total wages as measure for labor, an export dummy, the total costs of intermediate input as costs of production and total investments in tangible and intangible assets (FBS Data).
Foreign Group	Dummy variable equals to 1 if firm i is part of a foreign-owned group (equity greater than 50%) or 0 otherwise (LiFi Data).
French Group	Dummy variable equals to 1 if firm i is part of a French group (equity greater than 50%) or 0 otherwise (LiFi Data).
Foreign Ownership	The share of ownership of firm i by individuals and companies which are not based in France (LiFi Data).
Tot. R&D	Firm i total expenditure on R&D activities both internally and externally (R&D Inquiry).
R&D Intensity	Ratio of firm i total expenditure on R&D activities over total sales (FBS and the R&D Inquiry).
Product Innovation	Dummy variable equals to 1 if firm i has introduced a new product innovation as a result of R&D activity and 0 otherwise (R&D Inquiry).
Process Innovation	Dummy variable equals to 1 if firm i has introduced a new process innovation as a result of R&D activity and 0 otherwise (R&D Inquiry).
R&D	Dummy variable equals to 1 if firm i has started investing in R&D activities for the first time and 0 otherwise (R&D Inquiry).
Pd	Dummy variable equals to 1 if firm i has introduced a new product innovation for the first time and 0 otherwise (R&D Inquiry).
Pc	Dummy variable equals to 1 if firm i has introduced a new process innovation for the first time and 0 otherwise (R&D Inquiry).
PdPc	Dummy variable equals to 1 if firm i has introduced both a new process and a new product innovation for the first time and 0 otherwise (R&D Inquiry).
Ind	Industrial sector at the NACE 2-digit-level of disaggregation (FBS Data).
Year	Year fixed effect.
Region	Regional fixed effects. We follow the French official administrative structure according to which Metropolitan France is organized in 22 regions (FBS Data).